



# Re-Examining the Impact of Road Network Transportation on the Citizens' Social Welfare of the Mekong Delta of Vietnam

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## Abstract

**Purpose:** This study is undertaken in order to re-examine the impact of social indicators on the citizens' social welfare of four regions, including Can Tho, An Giang, Tien Giang, and Dong Thap, as well as clarify the role of road network transportation in relation to the influence on social welfare. **Research design, data, and methodology:** The research applied the panel data with 400 residents living in four provinces involving Can Tho, An Giang, Tien Giang, and Dong Thap over the period 2020 – 2022, among which the study employs the REM, FEM, and POLS approaches. **Results:** Firstly, road network connectivity positively affects the total income, total expenditure, and nonfarm income, while there is no statistical link between road network and working hours. Secondly, cultivated annual areas have a positive relationship with the total expenditure of households and a negative relationship with total income. Thirdly, there is no statistical evidence to conclude that Perennial areas, Forest areas, Water surface areas, Education, and Labor members influence total income, total expenditure, nonfarm income, and working hours. **Conclusions:** The policy implications should concentrate on improving the road network connectivity among provinces to widen the opportunity to approach more potential commercial markets as well as limit the cost of transportation for households.

**Keywords:** Social Welfare, Road Network Connectivity, Panel Data Analysis, Social Indicators, Southwest Region.

**JEL Classification Code:** C33, I31, R20, R40, R41

## 1. Introduction

The operation of agriculture and non-farming activities is advantageous for the development of the regional economy. According to Loizou et al. (2019), the region's economy cannot operate without farming activities, which even have strong relations with other socio-economic

elements such as the employment rate, household income, or the figure of manufacturing. Moreover, to be out of poverty, particularly in rural areas, the World Bank emphasized the roles of high-value farming operations, fostering non-farming migration between areas, and encouraging household non-farming activities (World Bank, 2007). Besides agriculture, shifting to non-farming income

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is considered more economically efficient than a traditional one. In Al-Amin and Hossain (2019) study in rural Bangladesh, scholars found that the poverty threshold can decline by encouraging better performance in non-farm finance. Having the same view, Moeis et al. (2020) suggested the advantages of these changes that households can have more financial resources when waiting for the next harvest or coping with crop loss. Tuyen and Huong (2013) also explained that despite the short-term reduction, the farmland loss does not cause a large decline in household income and expenditure Tuyen and Van Huong (2013).

There are many elements influencing the improvement of social welfare. First of all, transport accessibility, directly and indirectly, improves the regional resident's living quality. Transport connectivity limits manufacturing capacity and labor utilization, thereby considerably causing regional poverty (Ali-Nejadfard, 1999). Ahmed and Nahiduzzaman (2016) revealed that in developing countries, on account of underestimated transport systems, there are not many selections for poor households to approach different activities of the economy. They also emphasized two characteristics of transport development, especially in rural areas. Connectivity acts as the bridge between a market and other demand or supply resources in different regions. Moreover, more jobs such as architectural ones are requested for infrastructural schemes, providing temporary income opportunities for poor locals. People are motivated to participate in not only economic activities but also social programs by well-developed transport connectivity (Cuong, 2011). In a macroscopic view, the completion of transport infrastructure ensures the sustainability of regional living despite the impacts of climate change (United Nations, 2016). In Vietnam from 2004 to 2006, according to Cuong's study (2011), per capita income experienced an upward trend of 8.8% (or 858,000 VND) on account of regional road operations. The figure for household expenditure and working hours also went up. The more convenient road networks are, the more time locals spend on jobs. Thus, in order to enhance social welfare in regions, transport connectivity is one of the most crucial elements to evaluate.

Besides, land use, education, labor, and household size are important to improve social welfare. Farming manufacturing cannot be operated without land (Moeis et al., 2020). Even in industry, land is one of the fundamental assets and natural elements requiring strict management in the long run. According to The Ministry of Natural Resources and Environment in 2021, 114,000 hectares, 1,655,000 hectares, and 3,308,000 hectares of land were seriously, mediumly, and lightly degraded in Vietnam. These dilemmas influence significantly the figure and quality of production, indirectly causing income reduction in rural regions. Besides land utilization, X proposed that in this day and age, farmers must have moderate learning

levels so that they can easily approach advances in technology and have more opportunities to expose external markets (Awotide et al., 2016). Having the same perspectives, Nguyen et al. (2005) revealed that poor education is a barrier for farmers, causing unemployment in the period of industrialization. Household income or expenditure and other parts of society are also controlled by the number of members in a family. The smaller the family size is, the more their income achieve (Peichl et al., 2012). On the other hand, the large household size is an opportunity to shift into non-farming sectors (Al-Amin & Hossain, 2019).

In the South of Vietnam, Can Tho City, An Giang, and Dong Thap Province make remarkable contributions to agriculture, non-farm activities, and the general economy of the whole country. Being on the Mekong River Delta, these regions have prominent advantages of geography such as fertile lands, diverse natural water systems, and stainability of sub-equatorial climate. Mekong Delta is famous for rice growth and fruit plantings like mango, longan, pineapple, bananas, and others (Sebesvari et al., 2012). According to The Annual Economic Report 2022 of the Mekong Delta Region held by Vietnam Chamber of Commerce and Industry's Branch in Can Tho (VCCI) and Fulbright School of Public Policy and Management (FSPPM), agriculture took the incipient rate in the economy of this place and experienced the considerable upward 2 trend at 9.03% between 2015-2020, followed by the trivial increasing of industrial sector (4.39%) and service (3.82%). Can Tho Province is one of five municipal areas or big economic centers in Vietnam. Locating in the center of the Mekong Delta, this province is considered a crucial link between southwest regions and even national transport systems (WorldBank, 2023). Concomitantly, in 2022, Dong Thap achieved the fifth position of leading PCI (Provincial Competitiveness Index) compared to the whole country, accounting for 69.68 (Vietnam Chamber of Commerce and Industry, 2022), and still maintained this rank after years. As Dong Thap and Can Tho, An Giang is well-known for agriculture, especially aquaculture on account of having abundant water ecosystems (Sebesvari et al., 2012).

## **2. Literature Review**

Transport connectivity is the fundamental key to household welfare, especially in rural regions. Ahmed & Nahiduzzaman (2016) highlighted for the influences of transport accessibility of Chuadanga District in the southwest region of Bangladesh. They revealed that on account of given projects, low-income women can have more chances to be independent in finance. They can easily participate in external markets or cooperate with different

enterprises to develop handicraft merchandise. On the societal level, a well-developed transport network can help small and medium-sized enterprises' conditions and ensure the food supply and demands in remote regions. The regional economy is more dynamic and diverse based on various investors from other areas. According to the statistics of Viet Nam Household Living Standard Surveys collected by the General Statistics Office from 2004 to 2006 in Vietnam, the transport network influence considerably the household income rise, followed by a moderate relationship with expenditure. The study also emphasized that convenient transport systems in remote areas are the motivation for longer working hours, thereby leading to income growth. Accessibility creates more conditions for locals to approach income resources and indirectly impulses the expenditure, which performs as a sign for poverty decreasing. In contrast, there is no statistical conclusion for the influence of road network on non-farming income and education for 6-17-year-olds children (Cuong, 2011). However, in general, education is obviously galvanized by well-developed roads because of the travel cost decline and more access conditions. Moreover, transport networks are fundamental for social welfare, including creating education conditions since they not only help rural children easily to go to schools but also directly increase their parent's income (R. Khandker et al., 2009). Thus, transport is fundamental, affecting largely on most of the aspects of social welfare from income, and expenditure to the long-term elements such as education, and regional economy. These relationships will be analyzed in this research in the context of the Mekong Delta Region.

For some rural regions like Can Tho, Dong Thap, and An Giang Provinces, land utilization is essentially associated with social welfare. In research on Indonesia between 2000 and 2014, the scholars highlighted that the downward tendency of farming land resulted in the reduction of household expenditure since land for farming activities is the key element for agriculture (Moeis et al., 2020). In contrast, there is the point of view in Rondhi et al. (2019)'s study of East Java, Indonesia that the expansion of farming land is not aligned with economic development. They explained that planting non-farming crops on lands can provide more financial value instead of utilizing them for farming. The next reason is that manufacturing efficiency is not ensured because the more land farmers have, the worse the standard of input resources is (Rondhi et al., 2019). In the Vietnam rural case, after analyzing statistics from the 2018 Vietnam Household Living Standard Survey, Vu (2020) concluded that different types of land connect to households in different features. In particular, while annual cropland and forestland indicate negative relationships with income, contrast trends are observed for the cases of perennial cropland and aquaculture land (Vu, 2020). These

aspects of research are academically valuable to exploit the connection between land utilization and social welfare. In this study, according to the classification of land use in Article 10 of Vietnam Land Law 2024, the impacts of annual crop, perennial forest, and aquaculture lands on dependent variables will be clarified.

Many studies around the world also pinpoint the positive nexus between non-agricultural activities and social growth. Specifically, urban growth is recorded to have decreased poverty in both rural and urban. Especially, nonfarm income is an important contributor in reducing the poverty and income inequality in farmers at the level, depth, and severity (Kehinde & Ogundeji, 2023; Mat et al., 2012). Nonfarm income is sought to enhance the GDP, welfare of households, raise the assets of households (Watema et al., 2025). Jabbar et al. (2023) claimed that the diversification of nonfarm income helps to be less vulnerable in poverty.

Previous studies show that education is directly associated with non-farm income. Participating in primary, secondary, and tertiary school systems creates more opportunities to shift from farming activities to non-farming income (Al-Amin & Hossain, 2019). Vu (2020) revealed that individuals with high education have more relevant knowledge and skills to approach industrial markets. Moreover, it is more difficult to observe and analyze the skills in high-income households than the poor ones. This feature can be considered as the main reason why highly-trained workforce are more confident to get into the industrial sectors, even in advanced farming operations. For others, nonfarming activities are useful in urbanization, industrialization, and infrastructural development, which motivates households to escape from agriculture; however, this process is just appropriate for highly educated laborers (Tran et al., 2013). In this day and age, when the advance of technology controls mostly the operations in enterprises, qualified human resources with technology using skills and creativity are prioritized (Topel, 1999).

Besides education, the performance of labor and household size also contribute to the management of social welfare. These features obviously help to gain more manufacturing output as well as increase individual income. Collewet and Sauermann (2017) explained that the utilization of a process can be optimized by increasing working hours. However, long working hours can lead to fatigue and the efficiency of utilization goes down. Moreover, the scholars highlighted that the capacity of regional enterprises is fostered by different elements or variables relating to labor such as labor size, and qualified human resources, ... The contribution of household size varies for different regions. Al-Amin and Hossain (2019) believed that having many members in households is a positive condition to increase the ability to shift to non-farm sectors which helps to improve household income (Al-Amin

& Hossain, 2019). Household income or expenditure and other parts of the family are also controlled by a number of members of the family. Having the same opinion, Ali and Peerlings (2012) revealed in their research that having more children aged from 6 to 15 years old is advantageous in building industrial companies. Al-Amin and Hossain (2019) explained clearly that household income and assets are accumulated by independent members. In contrast, having more dependent members such as children or elderly in a family influence negatively on household saving and the process of asset accumulation (Bogan, 2015). Generally, the smaller the family size is, the more their income achieved; thus, demographic plans for small sizes should be encouraged to limit inequality and regional poverty (Peichl et al., 2012). On the other hand, the large household size is an opportunity to change into non-farming sectors. On account of these different conclusions, this research will also focus on identifying the actual trends in the given regions.

### 3. Research Methods and Materials

#### 3.1. Research Data

On the basis of a study by Cuong (2011), there are four dependent variables in this research, encompassing Total income, Total expenditure, Working hours, and Nonfarm income. These given variables are applied in order to evaluate the acceleration of economic growth and social welfare of four provinces, including An Giang, Tien Giang, Dong Thap, and Can Tho, over the period 2020 – 2022. In relation to independent variables, the study employs 11 components, among which 05 of them are dummy variables (including Road network, Province 1 for Can Tho, Province 2 for An Giang, and Province 3 for Dong Thap).

Table 1. portrays the measurable variables in this study.

**Table 1:** The Measurement Variables in the Model

	Description	Notation	Unit
Dependent variables	The household total income	Total_income	Thousand VND
	The household total expenditure	Total_expenditure	Thousand VND
	The working hours of households	Working_hours	Hour
	The proportion of nonfarm income of households	Nonfarm_income	%
Independent variables	Cultivated area	Areas_annuals	m <sup>2</sup>
	Perennial crop area	Perennial_areas	m <sup>2</sup>
	Forest area	Forest_areas	m <sup>2</sup>
	Water surface area	Water_areas	m <sup>2</sup>
	Education	Education	Year

	Description	Notation	Unit
	Total labor members of household	Labor_member	Person
	Total members of household	Total_member	Person
	Road network connectivity	Road_network	1 = Good network connectivity; 0 = Not good
	Can Tho Province	Province1	
	An Giang Province	Province2	
	Dong Thap Province	Province3	

Source: Cuong, 2011.

#### 3.2. Research Model Specifications

As mentioned above, because this study is based on the model of Cuong (2011), the general panel model is going to be illustrated to assess the influence of social components on household welfare in connection with the role of road network transportation as follows:

$$\begin{aligned}
 Total\_income_{ijt} &= \beta_0 + \alpha_{ij} + \beta_1 Annual\_areas_{it} \\
 &+ \beta_2 Perennial\_areas_{it} \\
 &+ \beta_3 Forest\_areas_{it} + \beta_4 Water\_areas_{it} \\
 &+ \beta_5 Education\_areas_{it} \\
 &+ \beta_6 Labor\_members_{it} \\
 &+ \beta_7 Total\_members_{it} \\
 &+ \beta_8 Road\_network_{it} + \beta_9 Province1_{it} \\
 &+ \beta_{10} Province2_{it} + \beta_{11} Province3_{it} \\
 &+ \beta_{12} \gamma_{20it} + v_j + \varepsilon_{it}
 \end{aligned}$$

$$\begin{aligned}
 Total\_expenditure_{ijt} &= \beta_0 + \alpha_{ij} + \beta_1 Annual\_areas_{it} \\
 &+ \beta_2 Perennial\_areas_{it} \\
 &+ \beta_3 Forest\_areas_{it} + \beta_4 Water\_areas_{it} \\
 &+ \beta_5 Education\_areas_{it} \\
 &+ \beta_6 Labor\_members_{it} \\
 &+ \beta_7 Total\_members_{it} \\
 &+ \beta_8 Road\_network_{it} + \beta_9 Province1_{it} \\
 &+ \beta_{10} Province2_{it} + \beta_{11} Province3_{it} \\
 &+ \beta_{12} \gamma_{20it} + v_j + \varepsilon_{it}
 \end{aligned}$$

$$\begin{aligned}
 Nonfarm\_income_{ijt} &= \beta_0 + \alpha_{ij} + \beta_1 Annual\_areas_{it} \\
 &+ \beta_2 Perennial\_areas_{it} \\
 &+ \beta_3 Forest\_areas_{it} + \beta_4 Water\_areas_{it} \\
 &+ \beta_5 Education\_areas_{it} \\
 &+ \beta_6 Labor\_members_{it} \\
 &+ \beta_7 Total\_members_{it} \\
 &+ \beta_8 Road\_network_{it} + \beta_9 Province1_{it} \\
 &+ \beta_{10} Province2_{it} + \beta_{11} Province3_{it} \\
 &+ \beta_{12} \gamma_{20it} + v_j + \varepsilon_{it}
 \end{aligned}$$

$$\begin{aligned}
\text{Working\_hours}_{ijt} = & \beta_0 + \alpha_{ij} + \beta_1 \text{Annual\_areas}_{it} \\
& + \beta_2 \text{Perennial\_areas}_{it} \\
& + \beta_3 \text{Forest\_areas}_{it} + \beta_4 \text{Water\_areas}_{it} \\
& + \beta_5 \text{Education\_areas}_{it} \\
& + \beta_6 \text{Labor\_members}_{it} \\
& + \beta_7 \text{Total\_members}_{it} \\
& + \beta_8 \text{Road\_network}_{it} + \beta_9 \text{Province1}_{it} \\
& + \beta_{10} \text{Province2}_{it} + \beta_{11} \text{Province3}_{it} \\
& + \beta_{12} \gamma_{20it} + v_j + \varepsilon_{it}
\end{aligned}$$

Whereas  $Total\_income_{ijt}$ ,  $Total\_expenditure_{ijt}$ ,  $Nonfarm\_income_{ijt}$ ,  $Working\_hours_{ijt}$  include total income, total expenditure, nonfarm income, and working hours components; the supcript  $i$ ,  $j$ , and  $t$  represent the household  $i^{th}$  in province  $j^{th}$  at the time  $t^{th}$ ;  $i = 1, 2, 3, \dots, n$  indexes the households (also cross-section),  $j = 1, 2, 3, \dots, n$  portray the provinces and  $t = 1, 2, 3, \dots, n$  expresses time;  $\alpha_{ij}$  refers to unobserved and time-constant factors affecting  $Total\_income_{it}$ ,  $Total\_expenditure_{it}$ ,  $Nonfarm\_income_{it}$ , and  $Working\_hours_{it}$ , respectively, while  $v_j$  is unobserved and time-constant province characteristics;  $\varepsilon_{it}$  refers to the idiosyncratic error, representing the unobserved factors that altered over time and affect  $Total\_income_{it}$ ,  $Total\_expenditure_{it}$ ,  $Nonfarm\_income_{it}$ , and  $Working\_hours_{it}$ .

Because this study applied panel data, which combines both cross-sectional and time units. This results in an increase in information and more variability because of the increase in the quality and quantity of data. The study employs three types of panel data models including pooled ordinary least-squares regression model (POLS), fixed effect model (FEM), and random effect model (REM) for our analysis into four given models. POLS estimates the model by stacking the entire observations across time and does not take into consideration the difference between cross-sectional units or time variations (Wooldridge, 2013). The expectation of the POLS model assumes that there are no unobserved individual effects, meaning that the entire cross-sectional units (or space units) share the same intercept and slope coefficients. This results in the higher value of  $R^2$  as well as the statistically significant coefficients; however, there also perhaps exists the auto-correlation phenomenon (Gil García, 2014). Besides, because of not considering the specification of the cross-sectional factors, the POLS model also does not clarify and explain the heterogeneity between these given factors. In order to control the cross-sectional units (space factors), FEM is employed with the assumption that each cross-sectional unit has a unique and time-invariant intercept. In the FEM, the slope coefficients across individuals are assumed to be constant. In contrast, the random effects model (REM) assumes that the unobserved individual effects are uncorrelated with the explanatory variables; concomitantly,

the intercept coefficient is considered a random variable instead of a constant value, influencing the individual differences across units. Hence, this individual-specific error is incorporated into the random component of the model rather than being treated as a fixed intercept, as in the Fixed Effects Model (FEM). In relation to the selection of model specification, in order to choose between POLS and FEM model, Wald test with F statistics is employed with the null hypothesis is Pooled OLS model is appropriate. Concerning the FEM and REM models, the Hausman test is selected to detect the valid model with the null hypothesis is REM model has been used when the p-value of the Hausman test is above 5% (Baltagi, 2021; Hausman & Taylor, 1981). Subsequently, with regard to the POLS and REM models, the Breusch – Pagan Lagrange test (also called the LM test) is employed with the null hypothesis that the POLS model is more consistent (Baltagi, 2021; Breusch & Pagan, 1980; Gujarati & Porter, 2009; Wooldridge, 2013).

Following that, this study continues to check the diagnosis test in order to guarantee the reliability of the model via checking the problems of auto-correlation and heteroscedasticity. In relation to the cross-section dependence, because the research just employs the micro-panel with two-time series and 400 cross-sectional units, the cross-section dependence does not influence significant problems, and thus, this study does not examine the cross-section dependence diagnosis. With regard to the problem of auto-correlation, the Breusch-Godfrey/Wooldridge test is employed with the null hypothesis that there is an auto-correlation phenomenon in the model (Baltagi, 2021; Hausman & Taylor, 1981). With respect to the heteroscedasticity problem, the Wald test with the null hypothesis is Heteroscedasticity. On the basis of the above diagnosis checking, in order to repair the auto-correlation and heteroscedasticity phenomenon, this study would employ strong standard robust models to solve the problems. The methods for repairing heteroscedasticity and contemporary correlation are portrayed specifically in section 4.

Furthermore, the research also checked the multicollinearity by considering the variance inflation factor (VIF). In general, the VIF values should be lower than 5, especially under 3, illustrating the reliability of the model (Kutner et al., 2004; O'Brien, 2007; Hair et al., 2010). The research utilized R studio and Eviews 13 software to estimate the model.

## 4. Results and Discussion

### 4.1. Statistical Descriptive Analysis

On the basis of the findings of descriptive analysis, in general, approximately 69.25% of the households in 4

provinces are approached by a road transportation network. Following that, in relation to the total income, the result showed that the average total income of households is 206,874 thousand VND, however, the median value is 173,612.5, illustrating that there is a significant disparity of total income between the households. The result of total

expenditure portrays that there is a great expenditure between households. The findings of the other factors, including working hours, nonfarm income, perennial areas, forest areas, water areas, education, and total members, are clarified in Table 2.

**Table 2:** Descriptive Analysis

	Mean	Standard deviation	Median	Min	Max	Skew	Kurtosis
Road_network	0.6925	0.4617	1	0	1	-0.8327	-1.3082
Total_income	206873.7100	120973.4818	173612.5	28710	851690	1.7030	3.8739
Total_expenditure	204968.1079	223550.5997	142168.5	12238	3722872	5.9067	77.1467
Working_hours	9.6313	1.7216	10	6	12	-0.4598	-0.5405
Nonfarm_income	47.4638	23.0162	50	10	100	0.6121	-0.3377
Areas_annuals	7870.3625	6517.5065	8000	0	40000	0.7311	0.7010
Perennial_areas	7798.2838	6275.0133	9000	0	50200	0.6499	1.7849
Forest_areas	604.3863	2260.9201	0	0	15000	4.0894	16.4806
Water_areas	4920.4643	4899.4998	4000	0	25000	0.8866	0.3281
Education	13.4400	3.1850	12	6	20	0.2568	-0.9630
Total_members	4.1000	1.1797	4	2	7	0.1261	-0.6748
Labor_members	2.5525	0.8878	2	1	5	0.5487	-0.3945

Source: The author's estimation.

## 4.2. Correlation Analysis

Before examining the regression of the model, the correlation relationship between factors is evaluated through a correlation matrix. Firstly, the correlation values among independent variables are generally low, except for some cases. Specifically, there is a very high correlation between the annual crop area and the perennial crop area, with a value of 0.94. Additionally, a strong correlation exists between the total number of household members and the number of household laborers, with a correlation value of 0.85. To avoid multicollinearity issues in the model and based on the importance of each variable, the study considers removing the total number of household members from the panel data regression model.

Secondly, road transportation infrastructure connectivity exhibits a slight positive correlation with all four dependent variables. This finding confirms that transportation infrastructure contributes to achieving sustainable economic development goals.

Thirdly, regarding total household income, the results indicate that independent variables generally have a negative correlation with the dependent variable, except for education, which shows no correlation. Meanwhile, total household expenditure exhibits a negative correlation with all independent variables. For the nonfarm income ratio, the results reveal a strong negative correlation with the annual crop area. Finally, working hours show a slight negative correlation with the independent variables.

**Table 3:** Example of a Table Caption (OLD Estimation Results)

	Road_network	Total_income	Total_expenditure	Nonfarm_income	Working_hours	Areas_annuals	Perennial_areas	Forest_areas	Aquaculture_areas	Education	Total_members	Labor_members
Road_network	<b>1.0000</b>	0.1032	0.0852	0.1671	0.1831	0.0414	0.0174	-0.0159	-0.0144	0.0164	-0.0078	-0.0277
Total_income	0.1032	<b>1.0000</b>	0.3558	0.1048	0.0195	-0.0426	0.0505	-0.0655	0.1111	0.1054	-0.0350	-0.0431
Total_expenditure	0.0852	0.3558	<b>1.0000</b>	0.0918	0.0427	-0.0549	0.0356	-0.0485	-0.0181	-0.0133	-0.0174	-0.0221
Nonfarm_income	0.1671	0.1048	0.0918	<b>1.0000</b>	0.0275	-0.2266	-0.1587	-0.0387	-0.0877	0.0683	0.0224	-0.0075
Working_hours	0.1831	0.0195	0.0427	0.0275	<b>1.0000</b>	0.0597	0.0029	0.0110	0.0908	-0.0322	0.0108	0.0082
Areas_annuals	0.0414	-0.0426	-0.0549	-0.2266	0.0597	<b>1.0000</b>	0.7495	0.1964	0.3901	0.0285	0.0651	0.0311
Perennial_areas	0.0174	0.0505	0.0356	-0.1587	0.0029	0.7495	<b>1.0000</b>	0.2567	0.3811	0.0121	0.0642	-0.0110

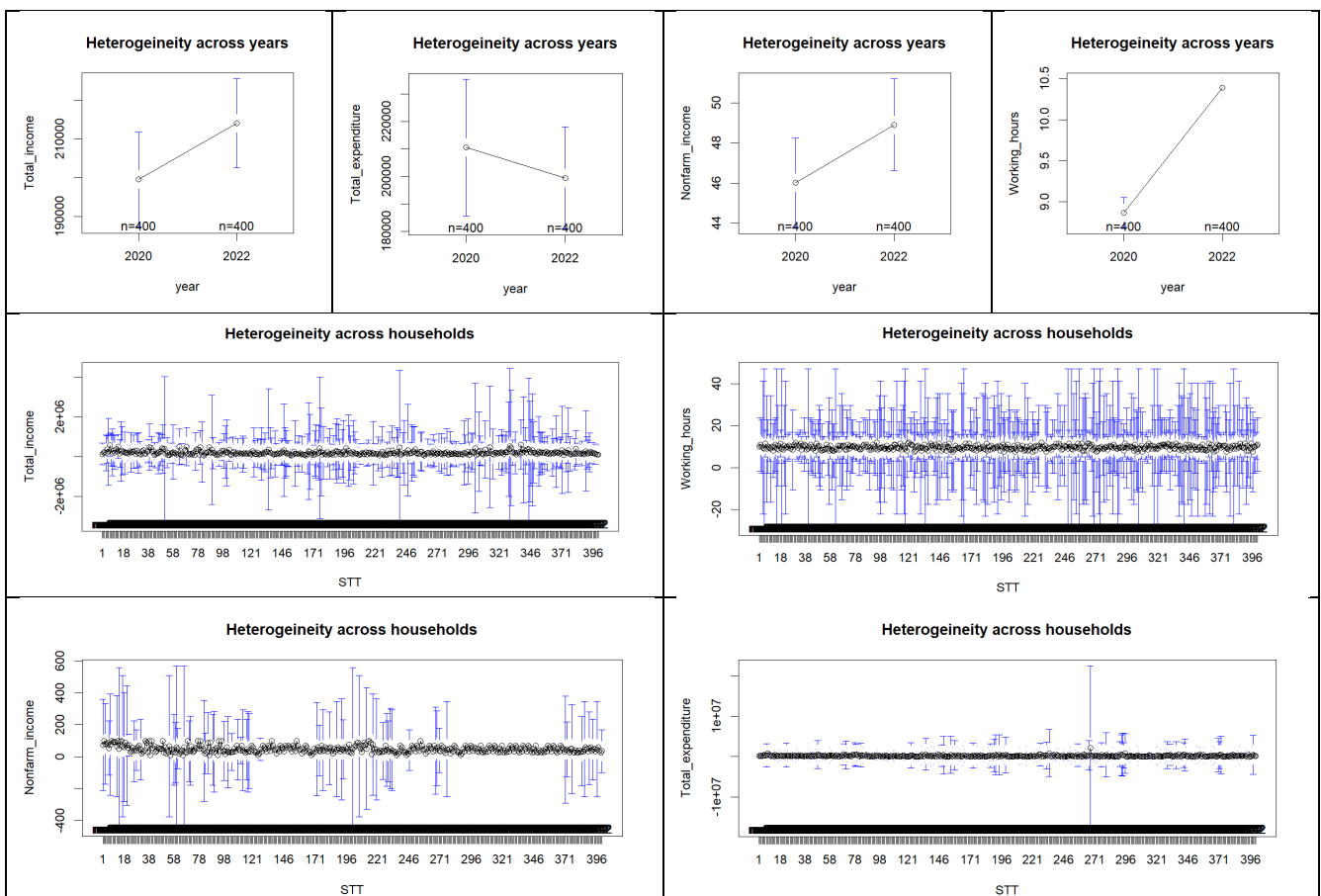
	Road_network	Total_income	Total_expenditure	Nonfarm_income	Working_hours	Areas_annuals	Perennial_areas	Forest_areas	Aquaculture_areas	Education	Total_members	Labor_members
Forest_areas	-0.0159	-0.0655	-0.0485	-0.0387	0.0110	0.1964	0.2567	<b>1.0000</b>	0.0920	-0.0055	-0.0092	-0.0077
Water_areas	-0.0144	0.1111	-0.0181	-0.0877	0.0908	0.3901	0.3811	0.0920	<b>1.0000</b>	0.0626	0.0086	0.0694
Education	0.0164	0.1054	-0.0133	0.0683	-0.0322	0.0285	0.0121	-0.0055	0.0626	<b>1.0000</b>	-0.0017	0.0175
Total_members	-0.0078	-0.0350	-0.0174	0.0224	0.0108	0.0651	0.0642	-0.0092	0.0086	-0.0017	<b>1.0000</b>	0.5901
Labor_members	-0.0277	-0.0431	-0.0221	-0.0075	0.0082	0.0311	-0.0110	-0.0077	0.0694	0.0175	0.5901	<b>1.0000</b>

Source: The author's estimation.

### 4.3. Heterogeneity Analysis

This research employs the “plot means” chart in R studio software to evaluate the heterogeneity between dependent variables in relation to the cross-sectional units and time by using the “gplot” package and command “plotmeans”. In the chart, the blue bars represent the 95% confidence intervals of the means values, while circular dots illustrate the mean points across individuals and periods. In case there are significant differences between the mean points and confidence

intervals, this expresses there are potential variations between cross-sectional units and time units. In doing so, the findings illustrate significant differences exist between Total\_income, Total\_expenditure, Nonfarm\_income, and Working\_hours across individuals and time. Specifically, at the individual level, these given components detail discrepancies in both mean values and confidence intervals. This details that households in the four provinces are recorded to have differed from one another and exhibit distinct characteristics. (see Figure 1).



Source: The author's estimation

Figure 1: Heterogeneity Analysis across Time and Individuals

#### 4.4. Selection of Appropriate Models

After considering the descriptive, correlation, and heterogeneity analysis, the study continues to check the best model selected among the POLS, FEM, and REM models through the F test (between the POLS and FEM), the LM test (between the POLS and REM), and Hausman test (between the FEM and REM). With respect to the Breusch–Pagan Lagrange Multiplier test (also known as the LM test), the results as detailed in Table 4, indicate that the models with Total\_income, Total\_expenditure, and Working\_hours as dependent variables all yield p-values smaller than the level of significance  $\alpha$  at 5% ( $p\text{-values} = 0.000 < \alpha = 0.05$ ). Hence, the REM models are selected for the case of these three models. Meanwhile, in relation to the model with “Working\_hours” as the dependent variable, the p-value is recorded to have been greater than the significance level of 5%, suggesting that the POLS model is appropriate in this case.

Following that, in order to select the REM and FEM models, the Hausman test is employed. The statistical results illustrate that the prob value of the Chi-square test in the Hausman test is smaller than the 5% level of significance with the “Total\_income” and “Nonfarm\_income” models, suggesting that the FEM model is applied for these two models. On the contrary, the p-value of Chi-square in the Hausman test for the “Working\_hours” and “Total\_expenditure” models, illustrates that the REM model is more appropriate for these two modes.

Finally, the F-test is applied to choose between FEM and POLS models. The results show that with regard to three models (Total\_income, Total\_expenditure, and Nonfarm\_incoem), the prob values of these models are smaller than 5% of the significance level. Therefore, the FEM model is applied to all three models. Conversely, because the p-value of the Working\_hours model is greater than 5% of the significance level, the POLS model is a more suitable selection (see Table 4).

**Table 4:** The Findings of Selections among Them FEM, REM Anf POLS Models

Testing the Suitability Between REM and POLS			
Model with the dependent variable	Chi-squared test	P-value	Conclusion
Total_income	8,6342	0,003299***	REM
Total_expenditure	8,1589	0,004285***	REM
Working_hours	0,60292	0,4375	POLS
Nonfarm_income	198,9	0,000000***	REM
Testing the Suitability Between FEM and POLS			
Model with the dependent variable	Chi-squared test	P-value	Conclusion
Total_income	1,4159	0,0002903***	FEM
Total_expenditure	1,3692	0,0009341***	FEM
Working_hours	0,95685	0,6691	POLS
Nonfarm_income	6,1537	0,000000***	FEM
Testing the Suitability Between FEM and REM			
Model with the dependent variable	Chi-squared test	P-value	Conclusion
Total_income	12,692	0,0482**	FEM
Total_expenditure	7,0029	0,3206	REM
Working_hours	6,9388	0,3265	FEM
Nonfarm_income	13,912	0,03064**	FEM

Source: The author's estimation

Note: the symbols \*, \*\*, and \*\*\* indicate the statistical significance levels of the regression coefficients at 10% ( $p < 0.1$ ), 5% ( $p < 0.05$ ), and 1% ( $p < 0.01$ ), respectively.

#### 4.5. Diagnosing Model Defect

Firstly, in relation to the multicollinearity test. The Variance inflation factor should not exceed 5 to guarantee there is no multicollinearity phenomenon in the model, ideally, the value should be lower than 3. The result detailed in Table 5 portrays that the likelihood of multicollinearity is less than 3, ensuring that the multicollinearity phenomenon does not exist in this model.

Secondly, regarding the autocorrelation testing. The research applied the Breusch-Godfrey/Wooldridge test to examine the presence of autocorrelation. The findings indicate that the p-value of the REM and POLS models are greater than 5% of the level of significance, suggesting that there is no statistical evidence to conclude the presence of autocorrelation. Meanwhile, in the two FEM models, the presence of autocorrelation is approved because the p-value is less than 5% of the level of significance.

Thirdly, heteroscedasticity testing. On the basis of the Breusch-Pagan test with the “bptest” conducted in R studio, the results concluded that all four models exhibit heteroscedasticity since the p-values are smaller than the level of significance at 5%.

In doing so, on the basis of the given diagnosis testing, it can be concluded that the REM and POLS models exist heteroscedasticity phenomena, while the two FEM models exhibit autocorrelation and heteroscedasticity in both. Therefore, in order to surmount these phenomena, the study employs the robust standard error model. In particular, in

relation to REM and POLS models, because of presenting heteroscedasticity, this research applies the “white1” method in order to adjust the standard deviation of coefficients to attain more reliability for estimating the model. The “white1” method is in the “plm” package in order to overcome the heteroscedasticity in the case of the non-autocorrelation phenomenon. This method is also a priority method for the REM model (Croissant & Millo, 2008). With regard to the FEM models, because of the presence of both heteroscedasticity and autocorrelation, the Arrelano method is employed to repair this phenomenon.

**Table 5:** Diagnosis Model Analysis

Variables	VIF values	Auto-correlation testing			
		Model with the dependent variable	Model	p-value	Conclusion
Road_network	1.232652	Total_income	FEM	0.0000***	The presence of autocorrelation
Areas_annuals	2.408891	Total_expenditure	REM	0.1494	No autocorrelation exists
Perennial_areas	2.432033	Nonfarm_income	FEM	0.0000***	The presence of autocorrelation
Forest_areas	1.193868	Working_hours	POLS	0.5041	No autocorrelation exists
Water_areas	1.314562				
Education	1.034650	Heteroscedasticity testing			
		Model with the dependent variable	Model	p-value	Conclusion
Labor_members	1.010854	Total_income	FEM	0.0000***	Heteroscedasticity
Province 1	1.585002	Total_expenditure	REM	0.0000***	Heteroscedasticity
Province 2	1.709021	Nonfarm_income	FEM	0.0000***	Heteroscedasticity
Province 3	1.570368	Working_hours	POLS	0.0000***	Heteroscedasticity
y22	1.227573				

Source: The author’s estimation

Note: the symbols \*, \*\*, and \*\*\* indicate the statistical significance levels of the regression coefficients at 10% (p<0.1), 5% (p<0.05), and 1% (p<0.01), respectively.

#### 4.6. Empirical Findings

The results of estimating models are detailed in Table 6. In the first, with respect to the “Total income” model, road network transportation has a positive impact on total income with a beta coefficient of 22,120 with a level of significance at 10%, meaning that the total income of households increases by approximately 22,120 thousand VND. This implies that the better the road network is enhanced, the greater the income welfare of citizens. When infrastructure transportation is developed, households widen their opportunities to access more potential markets in other provinces, improve their connections with investors as well as reduce transportation costs, ultimately increasing household income. This result is also in harmony with that of Khandker et al. (2009), Cuong (2011), Awotide, Peichl, PesTEL and Schneider (2012), Karimov and Diagne (2016). Following that, the finding of the “Areas\_annuals” variable explores that at the 1% significance level, an increase of 1 square meter in annual crop area leads to a decrease in total household income by approximately 14,6087 thousand VND. This suggests that the expansion of annual crop cultivation causes the reduction of household income. Positively, the negative relationship between annual crop

area and total household income reflects the ongoing economic shift from an agricultural-based economy to a non-agricultural economic activity. This finding is aligned with the result of Moeis et al. (2020). In addition, there is no statistical evidence to conclude that the variables “Perennial\_areas”, and “Water\_areas” have any impact on total income.

In the second, in relation to the model with “Total expenditure” as the dependent variable and chosen by the REM model, it can be observed that in the case of well-connected road infrastructure increases household expenditure by 59,944 thousand VND per year. Besides, the perennial\_areas variable impacts positively and significantly on total household expenditure by increasing 5,8544 thousand VND. In addition, the “Province 1” variable also contributes to the increase in household expenditure. Specifically, the expenditure of households in Can Tho is recorded to have been greater than that of Tien Giang province. This can be explained by the fact that in Vietnam, Can Tho province is one of the greatest centrally governed cities, thus, the cost of goods and services there is likely higher than in the other provinces in the Mekong Delta region, resulting in the higher total expenditures of households in Can Tho. This finding is also familiar with the

hypothesis that household expenditure in urban areas tends to be higher than in rural areas. On the contrary, the following variables “Annual\_areas”, and the dummy variable for the year 2022 negatively affect household expenditure. Concomitantly, there is no statistical evidence to conclude that the variables “Forest\_areas”, “Water\_areas”, “Education”, and “Total\_member” have an influence on household expenditure.

In the third, with the “Nonfarm income” model, the results illustrate that road infrastructure connectivity significantly and statistically affects the share of non-farm income for households in four provinces with the level of significance at 1%. Specifically, the well-developed road infrastructure increases the percentage of non-farm income by approximately 10% per year. This finding details that developing transportation infrastructure facilitates the growth of non-agricultural activities by enhancing the connectivity between provinces and promoting the households in these provinces into non-farm commercial activities. Additionally, households also have greater

opportunities to engage in non-agricultural business sectors, such as small enterprises and handicraft industries. Furthermore, as transportation infrastructure improves, tourism activities in the provinces also expand and develop, which in turn helps increase nonfarm income for households. There is no statistical evidence to suggest that annual crop area, perennial crop area, forest area, water surface area, education, and the number of laborers have an impact on the nonfarm income proportion of households in the four provinces.

In the fourth, with the “Working hours” model, the results from the POLS model indicate that the water surface area has an impact on household working hours in the four provinces. Additionally, compared to 2020, the year 2022 recorded an increase in working hours. Specifically, holding other factors constant, household working hours in 2022 were 1.4979 hours higher than in 2020. Moreover, the regression results also reveal that road transportation infrastructure has no effect on household working hours.

**Table 6:** Empirical Findings of the Regression

Model with the dependent variable	Total_income	Total_expenditure	Nonfarm_income	Working_hours
Type of model	FEM	REM	FEM	POLS
Road_network	22120.0601* [10295.83604]	59944*** [17347]	10.0033*** [1.6706]	0.0008 [0.14666]
Areas_annuals	-14.6087*** [5.09041]	-5.5894* [3.1668]	-0.0002 [0.0002]	0.0000 [0.0000]
Perennial_areas	1.8090 [1.26743]	5.8544 [3.7773]	-0.0008 [0.0003]	0.0000 [0.0000]
Forest_areas	-9.4671 [14.95446]	-2.4097 [3.0579]	0.0022 [0.0024]	0.0000 [0.0000]
Water_areas	-0.5667 [3.12607]	-0.4125 [1.5932]	0.0007 [0.0006]	0.0000** [0.0000]
Education		-2024.7 [2581.7]		-0.0220 [0.0185]
Labor_members		-2297 [8243.5]		0.0012 [0.0591]
Province1		48992*** [18027]		0.0261 [0.1553]
Province2		-21802 [20645]		-0.1315 [0.1702]
Province3		10783 [25844]		-0.0039 [0.1580]
y22	13338.5792 [8568.58720]	-31100* [16433]	-1.4173 [0.9687]	1.4979*** [0.1235]

Source: The author's estimation

Note: the symbols \*, \*\*, and \*\*\* indicate the statistical significance levels of the regression coefficients at 10% ( $p < 0.1$ ), 5% ( $p < 0.05$ ), and 1% ( $p < 0.01$ ), respectively.

## 5. Conclusions

Social welfare improvement is influenced by many factors, including transport connectivity economic opportunities, and social participation. The enhancement of infrastructure plays a pivotal role in creating temporary jobs

and improving resilience against climate change. Besides these given indicators, social welfare is also linked with the factors of land use, education, labor members, and so on. Therefore, this study is undertaken in order to investigate the impact of road network connectivity on social welfare as well as consider many social indicators in relation to the

impact on social welfare, including total income, total expenditure, the proportion of nonfarm income, and the working hours of residents in four Southwest provinces, encompassing Can Tho, Tien Giang, Dong Thap, and An Giang. The research employs panel data from two time periods and 400 individuals as well as apply the FEM, REM, and POLS models to assess the impact.

The results show that strengthening transport infrastructure positively impacts the total income, total expenditure, and the percentage of nonfarm income of households in the four provinces. Hence, the policy implication should be focused on enhancing the road network. Particularly, Road transport corridors should be planned carefully to ensure connectivity, leveraging the advantages of each transport mode to determine and allocate market shares appropriately. This approach aims to meet transportation demands and drive socio-economic development, especially in the four key economic regions. The connection between other roadways and expressways should be incorporated from the initial stages of expressway investment planning, in alignment with overall development plans. Developing the road network to ensure seamless connectivity, gradually eliminating geographical barriers between regions, reducing travel time, and redefining spatial concepts between localities. This will serve as a catalyst for accelerating urbanization in underdeveloped areas, expanding urban space, and easing pressure on major cities.

In addition, cultivated annual areas has a negative impact on total income and total expenditure. Hence, the policy implication should be concentrated on investing in transport infrastructure to connect production areas with related commercial markets in order to reduce logistic costs and increase product value. Besides, diversification of non-agricultural income is also promoted and encouraged, not only decreasing the dependence on annual crops but also enhancing the regional economy's resilience and sustainability.

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