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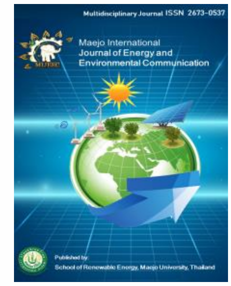

ARTICLE

An analysis of the new urbanization's ecological driving factor on the environment: based on the LMDI method

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ABSTRACT

The new urbanization policy emphasizes ecosystem friendliness. However, there is little research on new urbanization's effect on the ecological environment. This paper builds the LMDI model to decompose the ecological environment into three aspects: green area, wastewater discharge, and industrial solid waste production, to analyze the urbanization driving effect of Fujian Province in 2011-2018. The results show that the green area will increase due to economic-driven and urbanization-driven influences. Land-use-driven will cut down Wastewater discharge and waste generation. Among them, the economic-driven and land-use-driven have opposite effects.

1. Introduction

Urbanization is a process of population concentration (Tisdale, 1941). Usually, through population migration, many funds, resources, and populations are concentrated from villages to cities and towns to achieve regional economic development. The emphasis only on economic improvement has caused social structural changes, production factors flow, and industrial shifts. Urbanization often brings about environmental landscape changes, land-use conversion, and resource redistribution results. Especially the rapid resource transfer, for some ecological environments with low resilience stability, such changes will gradually increase the pressure on the ecological environment.

In order to alleviate the decline in the quality of human settlements caused by the pressure on the ecological environment, China put forward the goal of "new urbanization" at the 18th National Congress of the Communist Party of China in 2012. This goal puts "people" as the core of urban and rural development, emphasizing resource conservation, ecological environment friendliness, economic efficiency, harmonious community relations, and differentiated urban and rural development (Zhang, 2010). Therefore, to reduce the pressure on the ecological environment, exploring the driving factors of urbanization and the differences in their contributions is a critical issue to policymakers.

At present, the more popular method is to treat urbanization and the ecological environment as two systems. The urbanization system is usually composed of population, space, economy, and society. The ecological environment system usually refers to the Organization for Economic Cooperation and Development

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(OECD) and the Pressure-State-Response Model (PSR Model) proposed by the United Nations Environment Programme (UNEP) (Peng, Wu, et al., 2012; Jiang & Li, 2019). First is weighting the evaluation indicators of the two systems to measure the development status of the urbanization system and the ecological environment system in a specific geographical space. Then, using impulse response analysis to discuss the impact of urbanization on the ecological environment based on the evaluation results.

For example, (Liu, 2016) found that China's urbanization positively impacts the ecological environment, but it is suppressed in the 2nd phase, showing a coordinated development. Moreover, urbanization positively responds to ecological pressure, but it gradually weakens in the 4th phase and appears a long-term coordinated development. Urbanization has a weak negative response to the ecological state and a substantial negative impact on the ecological response in the initial stage, but it gradually weakens in the 3rd phase. (Guo & Zhang, 2018; Tian, Guo, et al., 2021) are all targeting provinces in China. They found that urbanization in the central and western regions, with weaker economic development, negatively impacts the ecological environment. China's western region, where the economy has developed, shows a weak negative or positive influence. Wang and Mao (2016) focused on the Wuling Mountain area of the Xiangxi Autonomous Region. They found that the impact of urbanization on ecological pressure and the environment has changed from negative to positive. Meanwhile, urbanization has a continued positive impact on the ecological response.

Other research methods include Chang and Guan (2020), focusing on provinces and cities in the Yangtze River Delta and establishing a stochastic frontier model to explore the impact of new urbanization on ecological efficiency. They found a U-shaped quadratic relationship between urbanization and eco-efficiency, but each province's timing of the inflection point is different. In addition, economic level, energy consumption, and the degree of opening-up all have a significant negative impact on eco-efficiency. Technological development has a significant positive impact on eco-efficiency. Xie, Chen, et al. (2018) used 284 prefecture-level cities in China to establish an IPAT dynamic panel model. They found that new urbanization, technological development, and the degree of opening-up have a significant positive impact on the ecological environment. The degree of affluence negatively impacts the ecological environment. In addition, there is a significant spatial dependence between the ecological environment of each city. The ecological environment of the surrounding cities has a significant negative impact on the target city. After decomposing, population urbanization, economic urbanization, and spatial urbanization negatively impact the ecological environment, and social urbanization positively impacts the ecological environment.

Basically, on the one hand, the impact of urbanization on the ecological environment will have different effects in regions with different levels of economic development. For areas with better economic foundations, as urbanization increases, even negative impacts on the ecological environment will gradually converge and stabilize in the long run. For the province-level, spatial differences will also cause urbanization to have different impacts on the ecological environment. That makes it more challenging to determine the impact on urbanization research at the national level or in large-scale areas. Therefore, we focus on the nine cities in Fujian Province. On the other hand, residuals cause different aspects of urbanization to impact the ecological environment.

2. Method

2.1 Logarithmic mean divisia index method

LMDI is a decomposition method, which quantitatively determines the size of each factor's influence on the research object analysis method, decomposing a complex thing into several relatively simple things as well as decomposing the extensive system into specific elements (Divisia, 1925 from Wu & Xu, 2014). The LMDI is a weighted average of relative growth rate derived from the Divisia index concept proposed by Divisia. Ang and Choi (1997, 2012) first introduced the log-average weight into the Index Decomposition Analysis (IDA) to study energy consumption and carbon emissions. LMDI has the following two advantages in application:

(A) It satisfies the characteristics of reversible factors, elimination of residual terms, no residual value, and consistent results regardless of the additive or multiplicative decomposition. Therefore, LMDI is more suitable for describing the internal effects of different industries or regions in an economy, as several new urbanization processes in prefecture-level cities or areas.

(B) Suitable for incomplete, discrete, and small sample data. The LMDI only needs a starting point and an ending point to logarithmic decomposition. Therefore, after implementing the macroeconomic policy, a post-event evaluation can be carried out earlier to quickly reflect the policy's effect.

2.2 Model design

Equation 1 shows a relationship of the urbanized ecological driving effect, which helps us analyze economic, land-use, and urbanization perspectives.

$$Y = \sum_{j=1}^{m} Y_j = \sum_{j=1}^{m} \frac{Y_j}{UCP_j} \cdot \frac{UCP_j}{CP_j} \cdot \frac{CP_j}{CDA_j} \cdot \frac{CDA_j}{CGDP_j} \cdot \frac{CGDP_j}{CP_j} \cdot CP_j \qquad (1)$$

In the left side, Y_j is the ecological quality and $Y_j \in \{CGA_j, WW_j, WS_j\}$. Where CGA_j is the Green Areas of Developed City, CGA_j is the total waste water, and 〖WS〗_j is the volume of industrial solid wastes produced. The advantage of this design is helping us to find out the driving effects of the same urbanization variable on different ecological environments by comparison.

In the right side, UCP_j is the urban population on census. CP_j is the total population on census. CDA_j is the developed area of the prefecture-level city. $CGDP_j$ is the gross domestic product of prefecture-level cities. j is the prefecture-level city in Fujian (Fuzhou, Xiamen, Putian, Sanming, Quanzhou, Zhangzhou, Nanping, Longyan, and Ningde).

Then equation 1 can be re-written as:

$$Y = \sum_{j=1}^{m} YUCP_j \cdot UCPCP_j \cdot CPCDA_j \cdot CDACGDP_j \cdot CGDPCP_j \cdot CP_j \qquad (2)$$

First, $YUCP_j$, $CGDPCP_j$, and CP_j refer to the economic effects. Where, $\frac{Y_j}{UCP_j} = YUCP_j$ is the per capita ecological variable. When $Y_j = CGA_j$, $YUCP_j$ is the developed area's per capita green area and reflects the degree of urban greening. The green area here refers to all kinds of green areas in cities and towns except for roof greening, vertical greening, and land covered with soil less than 2 meters. When $Y_j = WW_j$, it represents the total amount of wastewater discharged per capita, including industrial wastewater, living wastewater, and wastewater in centralized treatment facilities. When $Y_j = WS_j$, it is the amount of industrial solid waste generated per capita, which illustrates the degree of waste generated by urbanization. Due to data being hard to obtain, we use industrial solid waste to substitute for living waste production or the amount of living waste removed. $\frac{CGDP_j}{CP_j} = CGDPCP_j$ is the per capita GDP, reflecting the degree of social wealth. Generally, the large degree of urbanization has a high per capita GDP (Moomaw & Shatter, 1996).

Next, $CPCDA_j$ and $CDACGDP_j$ refer to the land-use effects. Where, $\frac{CP_j}{CDA_j} = CPCDA_j$ is the population density, and we use the developed area to replace the administrative area. Because the developed area is the town's economic and living activity area, it can reflect the actual degree of urbanization. $\frac{CDA_j}{CGDP_j} = CDACGDP_j$ is the eng, reflecting the effectiveness of urbanization on land use (Zheng, 2020). Usually, the denominator of this indicator is urban construction land, and we replace it with the area of developed areas. The main reason is that the area used for construction land belongs to the planned area of land use, while the area of developed areas results from actual land use, which better reveals the degree of urbanization. Besides, the data on the area used for construction land is incomplete.

Last, $\frac{UCP_j}{CP_j} = UCPCP_j$ is the urbanization rate to refer to the urbanizing effect, which we calculate as the proportion of the urban population in the permanent population. In general, the urbanization rate measures the urbanization of a region. A city or town has a higher urbanization rate means that more population is concentrated.

The structural formula for the LMDI additive factor decomposition analysis used in this research is adopted from Ang (2005) and presented in equation [3] to [9]. In an additive factor decomposition, the ecological quality increasing from period 0 to T can be decomposed based on the $\Delta YUCP_j$, $\Delta UCPCP_j$, $\Delta CPCDA_j$, $\Delta CDACGDP_j$, $\Delta CGDPCA_j$, and ΔCP_j. Therefore, the total increase (ΔY) is calculated by accumulate the rates of each effect.

$$\Delta Y = Y^T - Y^0 = \Delta YUCP_j + \Delta UCPCP_j + \Delta CPCDA_j + \Delta CDAGCDP_j + \Delta CGDPCP_j + \Delta CP_j \quad (3)$$

$$\Delta YUCP_j = \sum_j w_j \cdot ln\left(\frac{YUCP_j^T}{YUCP_j^0}\right) \quad (4)$$

$$\Delta UCPCP_j = \sum_j w_j \cdot ln\left(\frac{UCPCP_j^T}{UCPCP_j^0}\right) \quad (5)$$

$$\Delta CPCDA_j = \sum_j w_j \cdot ln\left(\frac{CPCDA_j^T}{CPCDA_j^0}\right) \quad (6)$$

$$\Delta CDACGDP_j = \sum_j w_j \cdot ln\left(\frac{CDACGDP_j^T}{CDACGDP_j^0}\right) \quad (7)$$

$$\Delta CGDPCP_j = \sum_j w_j \cdot ln\left(\frac{CGDPCP_j^T}{CGDPCP_j^0}\right) \quad (8)$$

$$\Delta CP_j = \sum_j w_j \cdot ln\left(\frac{CP_j^T}{CP_j^0}\right) \quad (9)$$

Where $w_j = \frac{Y_j^T - Y_j^0}{lnY_j^T - lnY_j^0}$ is are the weights of the additive form.

2.3 Data source and processing

All data are taken from the Fujian Statistical Yearbook 2010-2020 published on the Fujian Provincial Bureau of Statistics website. According to the start timing of the New Urbanization Plan made by the Fujian Provincial Development and Reform Commission, we split data into two ranges, 2011-2014 and 2014-2018.

3. Result and discussion

3.1 Driving effect of new urbanization on the green area

Figure 1 shows the additive decomposition of the green area (ΔCGA). First, the results show that Fujian has increased the green area by 7,197 hectares between 2011 and 2014. Moreover, it increased by 12,306 Hectares between 2014 and 2018. That reflects that Fujian has made a significant improvement in greening after implementing the "new urbanization" policy.

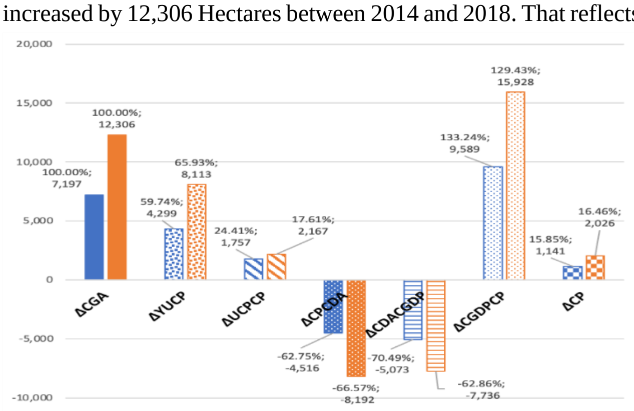

Figure 1 Additive Form for the ΔCGA.

Next, no matter how the government implemented the "new urbanization" plan, $\Delta YUCP$, $\Delta UCPCP$, $\Delta CGDPCP$, and ΔCP are the main positive driving effects. $\Delta CPCDA$ and $\Delta CDACGDP$ are the main adverse driving effects. Regarding the intensity of the effect, $\Delta CGDPCA$ is the most significant positive driving effect, contributing 133.24% in 2011-2014 and, provide 129.43% in 2014-2018. The second positive driving effect is $\Delta YUCP$. It contributed 59.74% before 2014 and increased to 65.93% after the "new urbanization" plan. Both population-related driving factors, $\Delta UCPCP$ and ΔCP, are relatively weak. They were 24.41% and 15.85% in 2011-2014 and declined to 17.61% and 16.46% in 2014-2018.

$\Delta YUCP$ and $\Delta CGDPCP$ have made a significant contribution to the degree of greening. Especially the growth of per capita GDP has made residents pay more attention to the quality of life. The increase in per capita green area may come from increasing the number of parks and park areas in Fujian. Fujian increased parks from 451 to 675 and increased park area from 9,681 hectares to 15,379 hectares between 2011-2018. The simultaneous expansion of the number and area of parks has also increased the green area per capita in developed areas.

Otherwise, green area increasing also benefited from the negative impact of $\Delta CPCDA$ and $\Delta CDACGDP$, which came from the decline in the population density of the developed area and the area of the developed area per unit of GDP. The decline in population density did not result from the decline in the population of Fujian, Rather, the population of Fujian still showed a slow upward trend from 2011 to 2018. Therefore, the decline in population density mainly results from expanding the developed area, which corresponds to the increase in the proportion of green space in the developed area mentioned above. In addition, the decrease in developed areas per unit of GDP reflects the increase in the efficiency of land use.

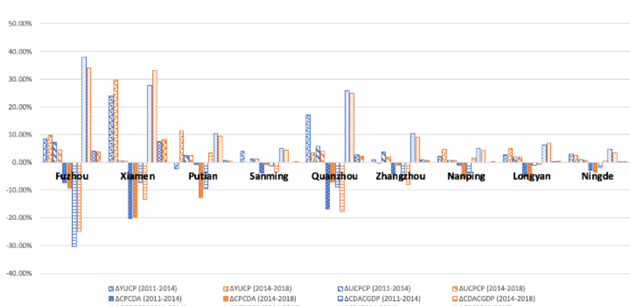

Figure 2 Greening driving effect of each city in Fujian.

Finally, we focus on the green driving effect of each prefecture-level city. (see Table 1 and Figure 2). Fuzhou, Xiamen, and Quanzhou have the most apparent driving effect. However, the driving factors of each city are slightly different. The driving effect of $\Delta YUCP$ has enhanced in Fuzhou, Xiamen, Putian, Nanping, and Longyan after the implementation of the "new urbanization" policy, and the enhancement effect of Putian is pronounced. Putian's greening impact of $\Delta YUCP$ before implementing the policy was -2.45%, but it grew to 11.44% after the implementation. However, $\Delta YUCP$ in Sanming, Quanzhou, Zhangzhou, and Ningde have declined after implementing the policy. Especially in Sanming and Zhangzhou, before implementing the policy, $\Delta YUCP$ was 3.87% and 0.77%, respectively, but it became -0.17% and -0.24% after implementing the policy. $\Delta CGDPCP$ has apparent positive driving effects in all cities except Xiamen and Longyan but lowered its influence after implementing the policy.

The negative impact of $\Delta CPCDA$ and $\Delta CDACGDP$ in most cities is still apparent. However, $\Delta CPCDA$ in Xiamen, Sanming, Quanzhou, Zhangzhou, and $\Delta CDACGDP$ in Fuzhou, Putian, Nanping, Longyan, and Ningde have declined after implementing the policy. Here, $\Delta CDACGDP$ in Putian and Nanping turned into a positive drive after implementing the policy. It shows that Putian and Nanping have made significant improvements in greening work after implementing the policy. After implementing the policy, Putian's green area increased from 0.75% to 14.29%.

3.2 Driving effects of new urbanization on the waste water

The wastewater discharge (ΔWW) in Fujian showed negative growth in 2011-2014, but after implementing the "new urbanization" policy, it showed positive growth of 65,008.07 metric tons (see Figure 3). The question is why the increase in wastewater discharge from negative to positive. Figure 3 shows the result of an additive decomposition of the wastewater discharge. First, we focus on the contribution of the driving factor. Before 2014, the reduction of wastewater discharge mainly results from three positive driving factors, $\Delta YUCP$, $\Delta CPCDA$, and $\Delta CDACGDP$. $\Delta UCPCP$ and $\Delta CGDPCP$ are the main negative driving factor. The $\Delta YUCP$, the most significant positive effect, is 146.00%, and $\Delta CGDPCP$, the most significant adverse effect, is -144.24%. After 2014, the increase in wastewater discharge results from the four positive driving factors, $\Delta YUCP$, $\Delta UCPCP$, $\Delta CGDPCP$, and ΔCP, contributed 55.71%, 26.90%, 160.61%, and 17.39%, respectively.

Figure 3 Additive Form for the ΔWW.

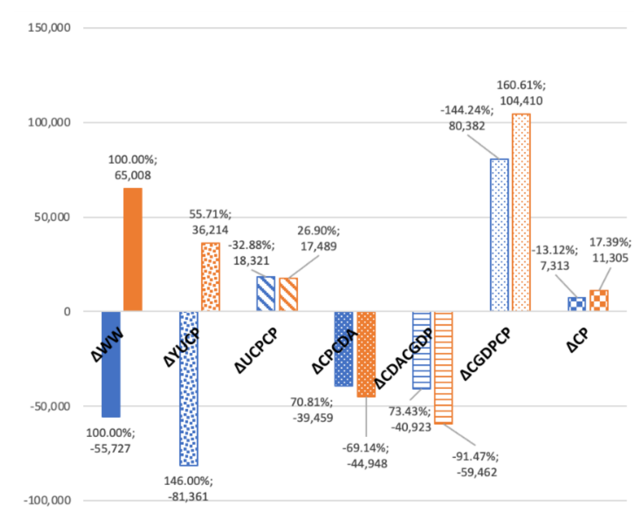

Table 1 ΔCGA for each city in Fujian.

ΔCGA	Fuzhou	Xiamen	Putian	Sanming	Quanzhou	Zhangzhou	Nanping	Longyan	Ningde
2011-2014	1427.00	2304.00	54.00	364.00	1840.00	377.00	184.00	360.00	287.00
2014-2018	2191.00	4716.00	1758.00	158.00	1163.00	307.00	691.00	894.00	428.00

Unit: tons

Table 2 ΔWW for each city in Fujian.

ΔWW	Fuzhou	Xiamen	Putian	Sanming	Quanzhou	Zhangzhou	Nanping	Longyan	Ningde
2011-2014	1764.82	2011.38	1515.59	-2173.94	1584.54	-60422.85	-779.84	112.24	660.62
2014-2018	14048.18	846.18	741.02	-7273.52	-9913.29	71730.11	-3431.92	-2191.06	452.37

Unit: tons

Moreover, $\Delta CPCDA$ and $\Delta CDACGDP$ is the main negative driving factor, with contributions of -69.14% and -91.47%, respectively.Next, we want to discuss whether the driving factor reverses the contribution effect due to the ΔWW reversal. Judging from the results, $\Delta CGDPCP$ is the main contributor to the increase in wastewater discharge. It seems reasonable to recognize that as economic development increases per capita GDP, it also causes more wastewater discharge. $\Delta UCPCP$ and ΔCP provide a weak and stable contribution to increasing wastewater discharge. As the urbanization rate and the population increases, wastewater discharge increases accordingly. Besides, $\Delta CPCDA$ and $\Delta CDACGDP$ are significant contributors to reducing wastewater discharge. Because of the land-use efficiency of cities and towns increasing reduced the generation of wastewater. Therefore, only $\Delta YUCP$ of contribution effect reversal occurs, which makes the leading cause of reversal of ΔWW.

In order to understand the reasons for the reversal of $\Delta YUCP$, We start a discussion with the urban population. The urban population increased by 8.89% from 2011 to 2014, and it increased by 10.19% from 2014 to 2018. Since the urban population growth rate has not declined, the reversal of $\Delta YUCP$ may result from the much increase in wastewater discharge. However, the discharge of wastewater in Fujian decreased almost year by year from 2011 to 2017, and it only increased in 2018, increased from 2,366,933,400 tons to 3,244,449,700 tons. We think that may result from Fujian's industrial added value growth rate in 2018, which hit a new high since 2015.

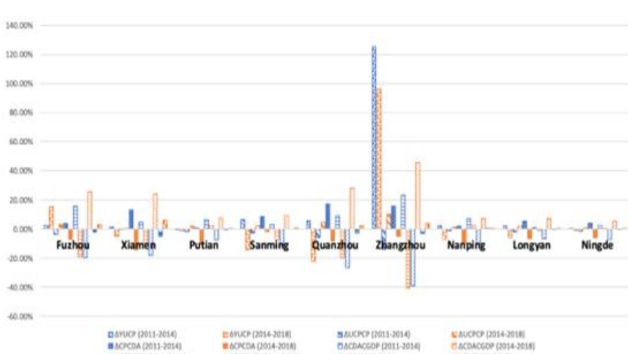

Figure 4 Wastewater driving effect of each city in Fujian.

At comparable prices, Fujian's GDP in 2018 increased by 9% compared to 2017, leading to a significant increase in wastewater discharge.

Finally, we discuss the effects of drivers of wastewater discharge from each prefecture-level city (see Table 2). From 2011 to 2014, the results show that Fuzhou, Xiamen, Putian, Quanzhou, Longyan, and Ningde have positively increased wastewater discharge, and Sanming, Zhangzhou, and Nanping experienced negative growth. Meanwhile, Zhangzhou's negative growth rate reached 108.43%, the primary source of negative growth. From 2014 to 2018, Fuzhou, Xiamen, Putian, Zhangzhou, and Ningde showed positive growth, respectively. However, Sanming, Quanzhou, Nanping, and Longyan showed negative growth. After implementing the policy, only Fuzhou and Zhangzhou increased wastewater growth. Among them, Zhangzhou has the highest positive growth rate at 110.34%. The growth of the remaining cities has declined.

Then, we focus on driving factors (see Figure 4). The driving factors of cities are similar to those of Fujian. $\Delta CGDPCP$, $\Delta UCPCP$, and ΔCP is still the driving factor of the steady positive growth of wastewater discharge, $\Delta CPCDA$ and $\Delta CDACGDP$ are the driving factors of steady negative growth. In addition, except for Zhangzhou, $\Delta CGDPCP$ in all cities are the main positive growth drivers. However, the impacts of $\Delta YUCP$ in each city were different. For example, $\Delta YUCP$ affected Zhangzhou, which resulted in a sizeable positive increase in wastewater discharge after the implementation of the policy. However, Xiamen, Putian, Sanming, Quanzhou, Nanping, Longyan, and Ningde showed adverse growth effects.

3.3 Driving effect of new urbanization on waste produced

Figure. 5 shows the additive decomposition of the waste production (ΔWS). ΔWS was 4.22 million tons before 2014 and 12.80 million tons after 2014, indicating that the amount of waste produced after implementing the policy has increased. Next, we focus on the driving factors $\Delta YUCP$, $\Delta UCPCP$, $\Delta CGDPCP$, and ΔCP are the main positive driving factors. They contributed 7.77%, 75.29%, 310.80% and 16.94% respectively before implementing the policy, and contributed 55.02%, 33.40%, 153.54% and 11.58% respectively after the implementation of the policy. $\Delta CPCDA$ and $\Delta CDACGDP$ is the main negative driving factor. Before implementing the policy, the contributions were -179.50% and -131.30%, and after the policy implementation, the contributions were -92.29% and -61.25%.

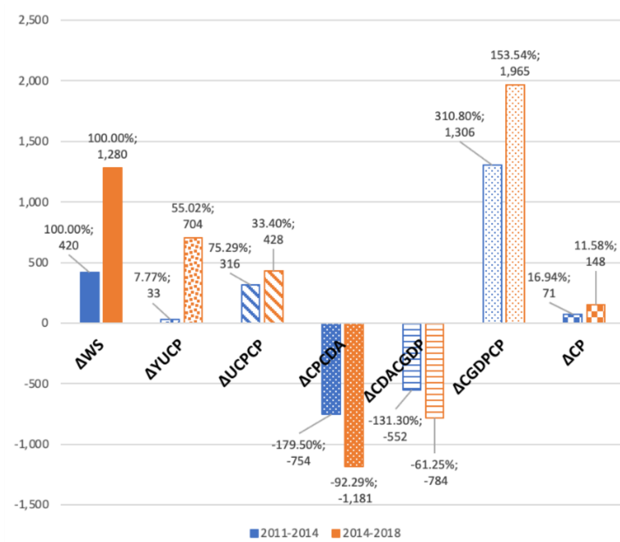

Figure 5 Additive Form for the ΔWS.

First, $\Delta CGDPCP$ is the main driving factor. In the light of the growth rate of permanent population and GDP. The growth rate of the permanent population in Fujian was 2.31% from 2011 to 2014 and 3.55% from 2014 to 2018. However, the GDP growth rate was 36.23% from 2011 to 2014 and 48.90% from 2014 to 2018. The high GDP growth rate reflects that the increase in waste production is mainly the result of economic output. Secondly, except for $\Delta YUCP$, we found that the impact of other driving factors has declined after implementing the policy. The amount of waste produced per capita has increased after implementing the policy. However, because $\Delta CGDPCP$ is still a solid positive growth effect and the negative growth effect of $\Delta CPCDA$ and $\Delta CDACGDP$ has declined, it is difficult to conclude that it is the main reason for the increase in waste generation.

Then, we pay attention to the changes in the driving factors of each city (see Table 3 and Figure 6). First, waste generation growth in Fuzhou, Xiamen, Quanzhou, and Nanping turned to negative growth after implementing the policy. $\Delta CGDPCP$ in these cities has shown a sharp decline, and $\Delta YUCP$ drives an increasingly negative effect. However, Fuzhou, Xiamen, and Quanzhou are all economically developed cities in Fujian. We believe that these cities have played a specific role in the lawmaking and implementing waste management policies. For example, Fuzhou launched the "Environmental Law Enforcement Training Activities" have achieved outstanding results in 2016. In 2015, Xiamen issued the "Regulation of Xiamen City Construction Wasteland Management," the "Regulation of Environmental Information Disclosure of Enterprises and Institutions," and the "Regulation of Environmental Protection Department's Implementation of Daily Continuous Punishment" and other related issues. The document strengthened waste management. Quanzhou has issued the "Quanzhou Ecological Environmental Protection Work Responsibilities Regulations" in 2017 to strictly implement environmental protection work responsibilities and strengthen management.

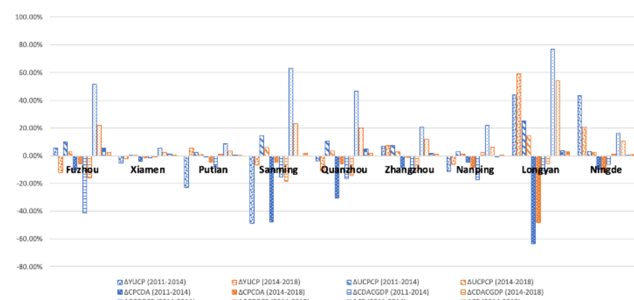

Figure 6 Waste produced driving effect of each city in Fujian.

After implementing the policy, the ΔWS in Putian, Sanming, Zhangzhou, Longyan, and Ningde increased. The main factor in these cities still results from $\Delta CGDPCP$'s strong positive growth impact. Among them, $\Delta YUCP$ and $\Delta CGDPCP$'s contribution in Sanming was -48.66% and 63.24% before implementing the policy, and the contribution after the implementation policy was -6.63% and 22.94%, respectively. Although the effect of waste production caused by economic development has declined, the negative growth effect of waste production per capita has also dropped significantly. $\Delta YUCP$ cannot compensate for $\Delta CGDPCP$, which increases the overall waste production after implementing the policy. In addition, Longyan's waste production has increased extensively after implementing the policy. That is because the negative growth effect of $\Delta CPCDA$ and $\Delta CDACGDP$ has decreased while the positive growth effect of $\Delta YUCP$ has increased.

Table 3 ΔWS for each city in Fujian.

ΔWS	Fuzhou	Xiamen	Putian	Sanming	Quanzhou	Zhangzhou	Nanping	Longyan	Ningde
2011-2014	88.46	-15.99	-84.87	-142.76	47.89	67.35	-38.82	303.22	195.58
2014-2018	-86.87	-16.76	86.01	14.20	-72.70	139.20	-58.92	976.46	299.24

Unit: tons

4. Discussion

Referring to the results above, we summery as three points to discuss.

1. The driving effect of $\Delta YUCP$ occurs at the micro level, and the driving effect of $\Delta CGDPCP$ occurs at the macro level. However, ΔCP is similar to the multipliers for $\Delta YUCP$, when $\Delta YUCP$'s driving effect is significantly more substantial than the effect of $\Delta CGDPCP$. For example, the wastewater discharge in Zhangzhou has increased significantly after implementing the policy. However, the increase in ΔCP has caused Zhangzhou to reverse the phenomenon before and after implementing the policy.

When the driving effect of $\Delta YUCP$ is significantly weaker than that of $\Delta CGDPCP$, $\Delta CGDPCP$ will dominate the main impact of driving. At this time, the number of residents increases to $\Delta CGDPCP$'s effect. For example, Xiamen's wastewater discharge still has a slight increase after implementing the policy, which is mainly due to the driving effect of $\Delta CGDPCP$ and ΔCP. At this time. However, the driving effect of Xiamen's per capita wastewater discharge has brought about negative growth. The driving effect has offset this effect.

Besides, $\Delta CGDPCP$ faces pollution emissions, i.e., wastewater and solid waste. The driving effect will show a negative growth effect, but in the physical construction of the ecological environment, i.e., green area, it will show a positive driving effect. For example, when decomposing the degree of greening, per capita GDP is a positive driving effect. It means that $\Delta CGDPCP$ has strong production characteristics. When used for physical output, $\Delta CGDPCP$ will have a perfect effect, such as parks, green belts, and another public greening, or construction of sewage treatment stations and waste recycling treatment. On the other hand, due to the production characteristics, $\Delta CGDPCP$ also has a negative driving effect similar to the product cost concept. For example, on the issue of wastewater discharge and waste generation.

Therefore, We believe that there are two key points to grasp the impact of output drivers on the ecology:

(1) Grasp the driving effect of $\Delta YUCP$.
(2) The impact of $\Delta CGDPCP$ is not necessarily negative. That also means that when enjoying the economic driving effect to bear the product cost, try to create an output conducive to the ecological environment.
(3) Suppose such output can match the driving effect of $\Delta YUCP$, such as proposing corresponding regulating documents, implementing environmental protection activities, strengthening environmental supervision, or improving management effectiveness.

In that case, the ecological construction benefits will be the greatest.

2. Great attention should be paid to the driving effect brought by land-use efficiency. The driving effect of land-use efficiency is the opposite of $\Delta CGDPCP$'s driving effect, especially the $\Delta CDACGDP$. For example, with the increase in GDP, the construction of parks gradually increases the degree of greenery, making the $\Delta CGDPCP$ positive driving effect on the degree of greenery. However, the increase in greenery does not increase the GDP, making land-use efficiencay decline. Therefore, land-use efficiency presents a negative driving effect.

When the policy produces ecological entity construction, the driving effect of land-use efficiency will have a negative growth effect. However, when faced with pollution emissions, land-use efficiency will have a positive driving effect. That means that when policies focus on reducing pollution emissions, they can enhance their driving effects by industrial agglomeration and improving land-use efficiency—for example, incentives for industrial land to increase floor area ratio and floors. When the policy emphasizes physical, ecological output, it can reduce land-use efficiency and increase the positive driving effect. Alternatively, renovate and revitalize idle buildings and land, or establish exit mechanisms to restore idle buildings and land to green spaces by planting grass, planting trees, and building parks.

3. Generally speaking, the increase in urban population will create demand for the physical construction of the ecological environment, so the urbanization rate has a positive driving effect on the construction of ecological entities. However, an increase in population will also bring about more emissions and pollution. Therefore, the rate of urbanization will have a negative driving effect on emissions. In addition, we also suggest that cities usually conduct environmental protection promotion or set up rules and regulations and audit standards. These methods increase the residents' environmental awareness and increase the positive driving effect of the urbanization rate.

Finally, the government should mix-use the economic, land-use, and urbanization strategies reasonably, set ecological goals to fit the region's traits, and then decide to increase or suppress the driving effect to obtain the best results on ecological environment construction.

5. Conclusion

In this study, we established an urbanization ecological driving effect decomposition model through the LMDI method. We conducted an in-depth discussion on the new urbanization driving effect of the three ecological environments of green area, wastewater discharge, and waste production. The results show different policy goals for urbanization, such as ecological construction or reduction of ecological pollution. It is worth noting that being limited by selecting data may cause a certain degree of deviation in the driving effect. Nevertheless, we believe that the results of this study provide a reliable and meaningful reference for decision-makers.

Declaration of competing interest

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

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