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# Household consumption characteristics and energy-related carbon emissions estimation at the community scale: A study of Zengcheng, China

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ABSTRACT

In recent decades, great changes have taken place in residents' lifestyle and consumption structure. Urban household consumption plays an increasingly significant role in promoting energy use and related carbon emissions. Communities are regarded as the basic part of city, and also units and cases where management methods and policies are most likely to be operated and implemented. In this paper, questionnaire surveys were administered to investigate the consumption characteristics of urban households at the community scale in Zengcheng. Based on statistical analysis, we assessed the consumption differences among the five selected communities. Meanwhile, the carbon emissions caused by household energy consumption (CEs-HE) were evaluated and the influencing factors were studied. The results showed that respondents from different communities had significant differences in their residential consumption, housing conditions, daily travel distance, public transport charge, household durable goods service life, monthly staple food consumption, and monthly energy consumption, respectively. The average CEs-HE of each household were 410.6 kg $CO_2$ per month. The Household demographic information, main expenditure items, housing conditions, daily travelling, family life habits and residents' environmental awareness all had significant impacts on CEs-HE. The results supplied in this study could provide some valuable information for decision-makers to explore the road of urban sustainable development.

## 1. Introduction

In recent years, China has been experiencing rapid economic development, population growth and urbanization, which has led to a sharp increase in energy consumption and carbon emissions (Fan et al., 2012; Ren et al., 2015; Zheng et al., 2011). Since 2008 and 2010, China has become the world's largest $CO_2$ emitter and the largest energy consumer respectively (Zhang et al., 2017). In 2018, the energy consumption of China accounted for 24% of global energy consumption and 34% of global energy consumption growth, and remained largest energy consumer in the world (Wang et al., 2021). To reduce carbon emissions, the Chinese government has taken substantial initiatives to promote low-carbon and energy efficient development. In the 13th Five-Year Plan, the government announced that the energy consumption per unit of GDP in 2020 should be 15% lower than that in 2015, and the total energy consumption should be limited to 5 billion tons of standard coal (GOSC, 2016). Meanwhile, the rapid development of China's economy has been coupled with the steadily growing household consumption over the last two decades, with an average annual growth rate of 34% (NBS, 2020). The growth in demand of domestic energy consumption was also high, with an average annual growth rate of 12.8% (NBS, 2020). This rapid increase was significantly associated with the rise of the residents' income and the change in the consumption patterns. For example, the household durable goods (such as refrigerators, air conditioners, computers, etc.) were purchased in more quantities and used more frequently. In fact, residential energy consumption has become an important source and growth point of energy demand and carbon emissions (Zhang et al., 2020), and its impact on energy and environment has attracted wide attention around the world (Chen et al., 2019; Lee and Lee, 2014; Perobelli et al., 2015; Ye et al., 2017; Zhou and Yang, 2016).

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In 2019, the proportion of China urban population was 60.6% (NBS, 2020), and the urbanization rate of China will exceed 80% by 2050 (Wei, 2014). On this condition, the household consumption has vast potential in the booming increase in the following years (Wu et al., 2019b). The increase of residents' consumption reflected the improvement of residents' living standards and the development level of the country, but it is not conducive to the implementation of energy-saving and emission reduction measures advocated by the government. Since changing consumer behavior is considered as an effective method for reducing energy consumption and related greenhouse gas emissions (GHG) (Dai et al., 2012), the analysis of urban household consumption behavior and carbon emissions is of great significance to the formulation of energy conservation and carbon emission reduction.

Previous researches indicated that the growing household consumption level is resulting in increasing emissions and wastes. Feng et al. (2015) found that the GHG caused by household energy consumption has represented more than 28% of all energy-related GHG in China. Ding et al. (2017) pointed out that the household sector had become the second largest consumer of final energy; approximately 26% of the total energy consumption and 30% of the $CO_2$ emissions were created by residential lifestyles and the related economic activities supporting the family needs (Wei et al., 2007). As a result, the carbon emissions caused by household consumption have become non-negligible. Households not only consume energy directly in the form of electricity and natural gas, but also use indirect energy associated with the production and transportation of all products (Fan et al., 2012). Therefore, the carbon emissions caused by household consumption can be divided into direct and indirect emissions correspondingly (Feng et al., 2020). Direct household carbon emissions (DHCE) are those associated with direct home energy consumption (such as transportation, cooking and warming) (Wei et al., 2007), while the indirect carbon emissions refer to that generated by the energy consumed of the commodities in their production, transportation and marketing (Mongelli et al., 2006). At present, a large urban-rural gap exists in terms of the sources and uses of energy (Zheng et al., 2014), and the impact on $CO_2$ emissions generated by urban households' energy consumption is larger than that of rural ones (Li et al., 2015; Zhang et al., 2017). The urban household consumption plays an increasing significant role in promoting energy use and related carbon emissions (Li et al., 2020; Shi et al., 2020; Yin et al., 2020) and the changes in family lifestyle and consumption patterns have become important components of reducing carbon emissions and energy consumption (Bin and Dowlatabadi, 2005). By guiding consumer behavior, the environmental impact of household consumption activities can be greatly reduced.

With the acceleration of China's economic process and social transformation, the urban community is developing at an unprecedented speed as an important institution to ease social contradictions and promote social harmony, which provides the residents with more than just a physical space (Yang et al., 2016). Community is the basic component unit of city and also a complete system, which connect society, public service and nature, moreover, it can represent the living standard, consumption concept and consumption pattern of the living group. Through its spatial characteristics and its integration with public services, as well as the extent of environmental pressure, it directly affects the resources required to support household activities. Ecological community, also known as green community or sustainable community, focuses on harmony between man and nature, aims to exert the ecological function of the community; it maintains community ecosystem balance through the use of modern ecological concept and technology, realizes high-efficient and recycling of resources and energy while reducing waste emissions, so as to build a comfortable and healthy human living environment with community-harmony, economic-efficiency, ecology-virtuous circle and development-sustainable conditions. In recent years, people's understanding of ecological communities have begun to develop, but few studies have linked the household carbon emissions of energy consumption to community attributes. There are many differences in the consumption of households in different regions and different types of communities and it is difficult to adopt a unified standard to measure the level of energy consumption and carbon emissions of residential communities. While discussing the main factors affecting carbon emissions at the urban scale cannot formulate targeted energy conservation and emission reduction policies for urban communities, the analysis of the household consumption characteristics and carbon emission at the community scale can reflect the problems existing in the current way of life in different communities more specifically and clearly, so as to provide targeted policies for decision makers to formulate emission reduction measures and develop low-carbon concept.

China has new started to apply low-carbon development concepts (Bai and Liu, 2013) and the government has been actively promoting the development of small and medium-sized cities in China. However, research is still required to better understand the role of small and medium-sized cities in improving regional sustainability as well as reducing the carbon emissions of metropolitan area. To this end, Zengcheng, a satellite city of Guangzhou, which has close relations with Guangzhou in terms of production and life, was selected as the research area in our research. In recent years, it has undertaken to disperse part of the population of Guangzhou, accepted the diffusion enterprises of Guangzhou, and shared the economic and demographic pressure of Guangzhou. Additional detailed informations about Zengcheng will be provided in the following section. Benders et al. (2006) found that when energy-saving measures are adopted for households, indirect energy cannot be significantly reduced while direct energy can be significantly reduced, so investigate the direct energy consumption and carbon emissions can provide a more effective reference for the formulation of emission reduction targets. In this study, we will take household daily living consumption as an entry point, compare the consumption behaviors of different types of community, analyze the direct carbon emissions caused by household energy consumption (CEs-HE) of different communities and explore the main influencing factors of CEs-HE, which can provide some guidances for the construction of different types of ecological communities in similar small and medium cities in China.

The rest of this study is as follows: Section 2 gives the methodologies and data collection for this research, Section 3 describes the results, Section 4 is the discussion and policy implications of this study, Section 5 presents the conclusion.

## 2. Methodology and data collection

### 2.1. Case study area

Zengcheng, a satellite city of Guangzhou in China, plays an important role in the development of Guangzhou. It expands the overall ecological capacity of Guangzhou by providing a large number of ecological services, so as to share the economic and population pressure (Zhang et al., 2017). It covers about 1616.47 $km^2$ and has a permanent population of 1.41 million. In recent years, Zengcheng has established three major function zones (Fig. 1). The restricted development area is located in the northern region, which mainly focuses on the development of urban agricultural eco-tourism and healthy leisure industry. The optimized development area is in the central region, which mainly develops the cultural and conference leisure industry, while the south region mainly develops emerging industry such as high-tech products, which is described as the major development area.

The urban households are crucial for implementing carbon emission mitigation policies in China. In the last 15 years, the proportion of urban household direct energy consumption in total energy consumption in Zengcheng has increased from 7.1% to 16.46%, more than two times, and so it is necessary to guide households to reduce energy consumption and carbon emissions. We selected five typical urban communities in Zengcheng district for questionnaire survey (Fig. 1). Paitan community (Paitan) is located in the restricted development of eco-tourism demonstration zone. Jinxiu community (Jinxiu) and Donghu community (Donghu) are located in the optimized development of cultural industrial

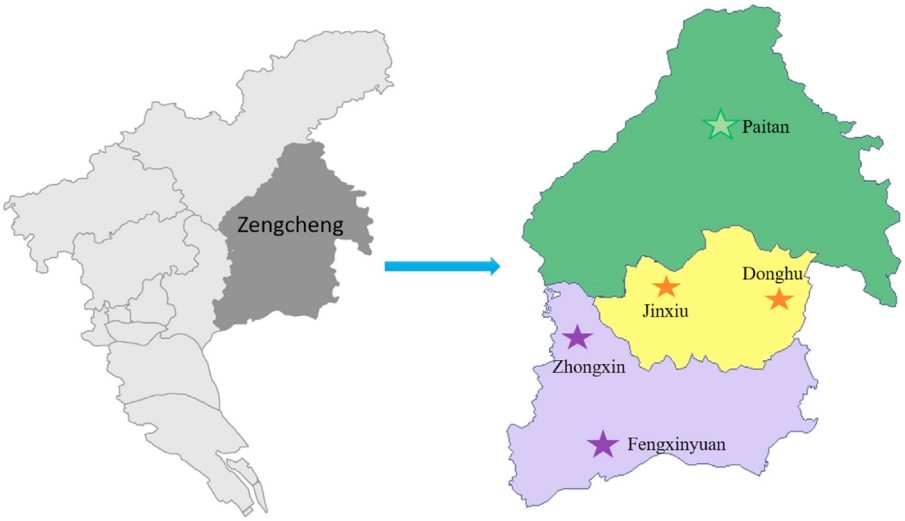



**Fig. 1.** The location of Zengcheng in Guangzhou and the five communities in Zengcheng.

areas, while Zhongxin community (Zhongxin) and Fengxinyuan community (Fengxinyuan) are located in the newly developed industrialized areas.

### 2.2. Survey

Face-to-face interviews are the best way to provide reliable results and high return rates (Wang et al., 2017). Therefore, we conducted a face-to-face questionnaire survey to analyze the consumption characteristics of residents in September and October 2015. The questionnaire survey was conducted among 393 residents in Zengcheng district with 100% return rate, which investigated the living standard, consumption characteristic, and environmental protection awareness of the household in the five communities.

The questionnaire consisted of the following parts:

Part 1: Respondents' demographic information (family size, occupation, educational level, physical condition).
Part 2: The proportion of respondents' various consumption in total consumption (food consumption, residential consumption, education and entertainment consumption).
Part 3: Respondents' housing Conditions (commodity house or not, housing ownership, inhabiting information, housing area and housing community).
Part 4: Respondents' traffic mode and consumption (daily travel distance, the most commonly used transportation, daily trip time, Monthly expenses for public transportation and private cars).
Part 5: Daily necessities consumption (the service life of household durable goods, average meat cost per month, monthly average cost of staple food).
Part 6: The main energy consumption in family life and monthly energy consumption (electricity, domestic water, coal, natural gas, gasoline, cooking at home per week, number of meals out).
Part 7: Environmental perception (satisfaction with garbage disposal, waste disposal methods, awareness of environmental changes, most concerned environmental issues, satisfaction with environmental protection).

### 2.3. Calculation methods

Based on the survey, we calculated the main energy consumed by the respondents including domestic electricity, natural gas, coal and gasoline. Since the public transport produces relatively less energy consumption and carbon emissions than domestic transport, in consideration of the availability of data, we only considered the energy use of domestic cars and motorcycles in this study. The primary data used was obtained from the questionnaire survey. The carbon emission from direct energy consumption can be formulated as:

$$CEHE = \sum_i (F_i \times CO_2\_coefficient)$$

where *CEHE* is carbon emission from direct energy consumption, $tCO_2$; $F_i$ is the consumption of fuel *i*, *i* is the kind of fuels. $CO_2\_coefficient$ is the carbon coefficient of fuel *i*. The coefficients of coal, oil and natural gas are from China greenhouse gas inventory study (NDRC, 2007b), and the coefficient of electricity is from the Benchmark emission factor from China's regional power grid (NDRC, 2007a).

### 2.4. Statistical analyses

All the survey data were analyzed by SPSS 21 software. The respondents' basic information and consumption characteristic were analyzed by descriptive statistics. Analysis of variance and Kruskal-Wallis tests were used to analyze the household consumption differences among the five communities. Finally, we used regression analysis to determine the influencing factors of carbon emissions from energy consumption, as well as the correlation among them and the degree of correlation.

## 3. Results

### 3.1. Respondents' household consumption differences among the five selected communities

Statistical analyses of the surveys were shown in Table 1. Respondents from different communities had significant differences in their proportion of residential consumption in total consumption. No significant differences were found in their proportion of food consumption, educational and entertainment consumption among households in the five communities.

In the aspect of housing conditions, respondents from different communities had significant differences in their room type, housing ownership and housing area.

Different communities affected the respondents' daily travel distance and public transport charge. No significant differences were observed in daily travel time and private care cost among the five selected communities.

The household durable goods service life of the respondents in the

**Table 1**
Household consumption differences among 5 communities.

| | Paitan | Jinxiu | Donghu | Zhongxin | Fengxinyuan |
|---|---|---|---|---|---|
| N | 64 | 98 | 85 | 66 | 80 |
| **The proportion of major consumption types in total consumption** | | | | | |
| Food[1] | 2.38±0.061 | 2.55±0.087 | 2.53±0.070 | 2.33±0.077 | 2.38 ± 0.078 |
| Residence[2] | 2.56±0.126$^{a}$ | 2.10±0.085$^{b}$ | 2.27±0.100$^{ab}$ | 2.30±0.116$^{ab}$ | 2.65±0.111$^{a}$ |
| Education and recreation[3] | 2.00±0.109 | 1.79±0.095 | 1.78±0.066 | 1.76±0.085 | 1.78±0.092 |
| **Housing conditions** | | | | | |
| Commodity house or not[4] | 0.50±0.063$^{ac}$ | 0.78±0.042$^{bc}$ | 0.47±0.054$^{a}$ | 0.48±0.062$^{ac}$ | 0.68±0.053$^{c}$ |
| Housing ownership[5] | 1.38±0.076$^{a}$ | 1.11±0.032$^{b}$ | 1.34±0.052$^{a}$ | 1.36±0.067$^{a}$ | 1.30±0.052$^{ab}$ |
| Inhabiting information[6] | 1.50±0.063 | 1.47±0.051 | 1.35±0.052 | 1.39±0.061 | 1.43±0.056 |
| Housing area[7] | 3.31±0.146$^{a}$ | 3.60±0.114$^{b}$ | 3.08±0.147$^{a}$ | 2.64±0.146$^{a}$ | 3.03±0.122$^{ab}$ |
| **Traffic mode and consumption** | | | | | |
| Daily travel distance[8] | 2.69±0.212$^{a}$ | 2.09±0.104$^{b}$ | 2.53±0.142$^{ab}$ | 2.94±0.170$^{a}$ | 2.38±0.156$^{ab}$ |
| Daily trip time[9] | 2.81±0.195 | 2.50±0.134 | 2.61±0.134 | 2.39±0.158 | 2.95±0.151 |
| Public transport charge[10] | 2.69±0.270$^{a}$ | 2.34±0.185$^{ab}$ | 1.91±0.158$^{b}$ | 2.12±0.209$^{ab}$ | 2.65±0.197$^{a}$ |
| private car cost[11] | 2.19±0.200 | 2.56±0.143 | 2.16±0.179 | 2.58±0.162 | 2.23±0.143 |
| **Daily necessities consumption** | | | | | |
| Household durable goods service life[12] | 1.88±0.098$^{a}$ | 2.10±0.109$^{ab}$ | 2.22±0.072$^{b}$ | 1.85±0.106$^{a}$ | 2.10±0.075$^{ab}$ |
| Monthly meat [13] | 3.31±0.203 | 3.73±0.165 | 3.06±0.173 | 3.55±0.178 | 3.25±0.193 |
| Monthly staple food [14] | 3.56±0.194$^{a}$ | 3.66±0.134$^{a}$ | 2.71±0.142$^{b}$ | 3.36±0.164$^{a}$ | 3.28±0.153$^{ab}$ |
| **Monthly Energy consumption** | | | | | |
| electricity [15] | 3.63±0.177$^{ab}$ | 3.79±0.129$^{a}$ | 3.19±0.143$^{b}$ | 3.33±0.163$^{ab}$ | 3.23±0.143$^{b}$ |
| Domestic water[16] | 2.50±0.161$^{a}$ | 3.18±0.150$^{b}$ | 2.60±0.160$^{a}$ | 2.55±0.140$^{a}$ | 3.00±0.180$^{ab}$ |
| Coal[17] | 0.69±0.188$^{ab}$ | 0.35±0.094$^{b}$ | 0.61±0.131$^{ab}$ | 0.88±0.132$^{a}$ | 0.25±0.065$^{b}$ |
| Natural gas[18] | 2.94±0.294$^{ab}$ | 3.71±0.208$^{a}$ | 2.41±0.237$^{b}$ | 3.55±0.239$^{a}$ | 3.15±0.193$^{ab}$ |
| Gasoline[19] | 2.75±0.254$^{ab}$ | 3.46±0.185$^{a}$ | 2.68±0.213$^{b}$ | 3.15±0.201$^{ab}$ | 2.83±0.157$^{ab}$ |
| Cooking at home per week[20] | 3.06±0.137 | 3.14±0.110 | 2.81±0.124 | 3.15±0.156 | 2.90±0.151 |
| Number of meals out[21] | 1.88±0.098$^{a}$ | 2.46±0.104$^{b}$ | 2.19±0.115$^{ab}$ | 1.79±0.139$^{a}$ | 2.15±0.114$^{ab}$ |
| **satisfaction with the infrastructure and the environment** | | | | | |
| Satisfaction with garbage disposal[22] | 2.88$^{ab}$ | 2.54$^{b}$ | 2.79$^{ab}$ | 3.03$^{a}$ | 2.85$^{ab}$ |
| waste disposal methods[23] | 1.94$^{a}$ | 2.04$^{a}$ | 2.31$^{b}$ | 2.12$^{ab}$ | 1.95$^{a}$ |
| Environment change[24] | 1.38$^{a}$ | 1.64$^{ab}$ | 1.62$^{ab}$ | 1.85$^{b}$ | 1.73$^{b}$ |
| Most concerned about the environment[25] | 2.750$^{ab}$ | 3.082$^{b}$ | 2.800$^{ab}$ | 2.455$^{a}$ | 3.250$^{b}$ |
| Satisfaction of environment management[26] | 2.44$^{a}$ | 2.50$^{ab}$ | 2.73$^{abc}$ | 2.85$^{b}$ | 2.93$^{bc}$ |

Values are presented as the mean±standard error. Different letters denote significant differences at $p < 0.05$.
[1-26] The detailed information is given in the Appendix.

five selected communities were investigated. The household durable goods in this study refer to the electrical appliances with long service life, such as television sets, washing machines, refrigerators, air conditioners, computers and so on. As shown in Table 1, different communities influenced the service life of household durable goods. When it comes to the expense of staple food, significant differences could also be found among the five communities. However, there was no significant difference in the average monthly meat consumption among the five communities.

We also investigated the energy consumption characteristics of the respondents' households, including electricity consumption, domestic water consumption, coal consumption, natural gas consumption, gasoline consumption, the frequencies of cooking at home per week and eating out monthly. The analysis showed that the households in the five communities had significant differences in all aspects except the number of meals cooked at home per week.

Besides, different communities affected the satisfaction with garbage disposal, garbage disposal method, perceptions of the environmental change trends, most concerned environmental issues and the satisfaction of environment management, respectively.

### 3.2. Carbon emissions of household energy consumption

Based on the survey, the direct carbon emissions caused by electricity (Ces-he), coal (Ces-hc), natural gas (Ces-hn) and gasoline (Ces-hg) consumed in daily life were calculated respectively. The results showed that the CEs-HE of each household were 410.6 kg $CO_2$ per month, which were 72% of the average $CO_2$ emissions from household consumption of China in 2012 (565.7 kg per month) (Wu et al., 2019a). The detailed carbon emission information of the five selected communities was shown in Fig. 2. Jinxiu produced the highest CEs-HE (451.4 kg$CO_2$), Ces-he

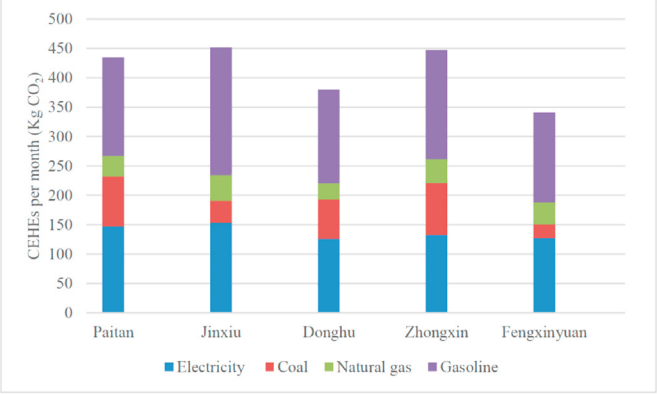



**Fig. 2.** Monthly carbon emissions of the five communities per household (Kg $CO_2$).

(153.75Kg$CO_2$), Ces-hn (43.67 Kg$CO_2$) and Ces-hg (216.88 Kg$CO_2$) monthly, and it could be explained that the household energy consumption of Jinxiu community was high, especially the gasoline. Among the five communities, the household in Paitan had the least income level, but the carbon emissions was not the least (Fig. 2). According to Zhang et al. (2020), the type of energy consumed by a household is related to the income, and the Low-income households are more likely to choose cheaper energy. The residents in Pitan consumed large amount of coal, which resulted in high carbon emissions. Among all types of energy consumption carbon emissions, Ces-hg accounted for the largest proportion, followed by Ces-he and Ces-hc. The residents in Zhongxin consumed more coal in their daily life than the other four communities,

and so the Ces-hc was the highest in the five communities. However, Fengxinyuan community, which is also located in the major development area in the south, produced the lowest CEs-HE monthly (340.7632 $KgCO_2$). This is because the household in this community consumed a small amount of coal. Since the natural gas belongs to clean energy, although the natural gas was the main energy for household daily consumption in the five communities, the proportion of Ces-hn was low.

## 4. Discussion and policy implications

### 4.1. Specific consumption characteristics of the five communities

#### 4.1.1. Respondents household various consumption in total consumption

In terms of residential consumption, the differences among Jinxiu, Paitan and Fengxinyuan were shown in that the number of households with no consumption in Jinxiu was significantly larger than that in Paitan and Fengxinyuan, and the number of respondents whose residential consumption accounts for 60%–80% of the total consumption was significantly smaller than the two communities (Fig. 3). This reflected that the living standard of the household in Jinxiu community was higher than other communities.

In terms of the overall level of the survey, most respondents indicated that food consumption accounted for 15%–30% of the total consumption. Feng et al. (2020) indicated that Chinese household food expenditures accounted for 36.5% of the total consumption in 2007, higher than the average of Zengcheng. When it comes to education and entertainment, the majority of respondents spent less than 30 percent of total consumption, and only 1.8% spent more than 80% of their total consumption.

#### 4.1.2. Respondents' housing conditions

Respondents in Jinxiu have more commercial housing than the respondents in other communities. In addition to Fengxinyuan, Jinxiu has significant differences compared to other three communities. Statistical significance was found between Donghu and Fengxinyuan regarding the housing property.

Different communities also affected the housing ownership, specifically, except Fengxinyuan, there were significant differences between Jinxiu and other three communities (Table 3). As shown in Fig. 4(a), the proportion of respondents in Jinxiu that purchased houses was higher than respondents in the other four communities, which reflected that the living standard of residents in Jinxiu was higher than that of the others. Paitan had the highest proportion of rental housing, which reflected that the living standard of residents in Paitan was relatively backward. As shown in Fig. 4(b), the living space of households and the proportion of households with a housing area of more than 100 $m^2$ were both higher in Jinxiu. However, there was no significant difference among the other four communities. Jinxiu community, locates in the central area of Zengcheng, in an optimized development area with an excellent ecological environment and sustainable economy. The respondents in Jinxiu have higher requirements on the quality of residence. Paitan is located in the restricted development zone with some tourist attractions and underdeveloped commerce, and the respondents in this area have lower level of income and fewer income sources. Yu et al. (2020)) indicated that tourism development is an effective way to enhance the livelihood of the inhabitants in the surrounding communities. Therefore, under the premise of the strictest protection, the recreation, research and education should be fully developed in the restricted development zone, so as to improve the living standard of residents in Paitan community.

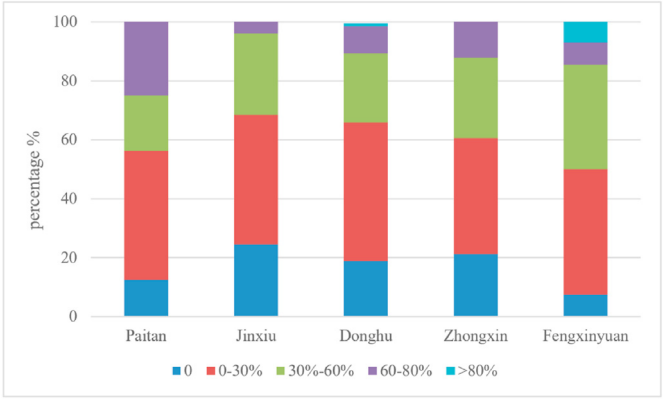



**Fig. 3.** The proportion of residential consumption in total consumption.

#### 4.1.3. Respondents' traffic mode and consumption

As shown in Fig. 5(a), 73.5% of respondents from Jinxiu travelled less than 5 km on a daily basis, making the shortest average travel distance among the five communities, while more than 50% of respondents from Zhongxin and Jinxiu travelled more than 5 km every day, with the longest average travel distance.

The average daily travel time of interviewees in Jinxiu, Zhongxin and Donghu was much shorter than other two communities, with about 15–45 min. The reason may be that the three communities are close to the major business districts and the life of residents in these communities is much more convenient than that of other two communities. On the other hand, the average travel time of the respondents in Fengxinyuan was the longest, this may because that Fengxinyuan is located in the major development area in the south, many residents in the community working in Guangzhou, causing the daily travel time increased.

Fig. 5(b) showed the average monthly spending on public transport. Respondents in Paitan and Fengxinyuan spent more than those in other communities, while respondents in Donghu community had the lowest cost, with only 9.5% of respondents spent more than 250 yuan. Besides, Zhongxin and Jinxiu had the highest cost of private cars. In the choice of daily travel modes, residents in Fengxinyuan, Jinxiu and Zhongxin used private cars more frequently, while those in Paitan community were more likely to choose walking and electric bicycles, and those in Donghu community most frequently used electric bicycles (Fig. 6).

#### 4.1.4. Respondents' daily necessities consumption

Most of the household durables in the five communities were maintained at 5–8 years (Fig. 7). However, Donghu had higher proportion of the household durables service life in 8–10 years than other communities, and also had higher average life of household durable goods.

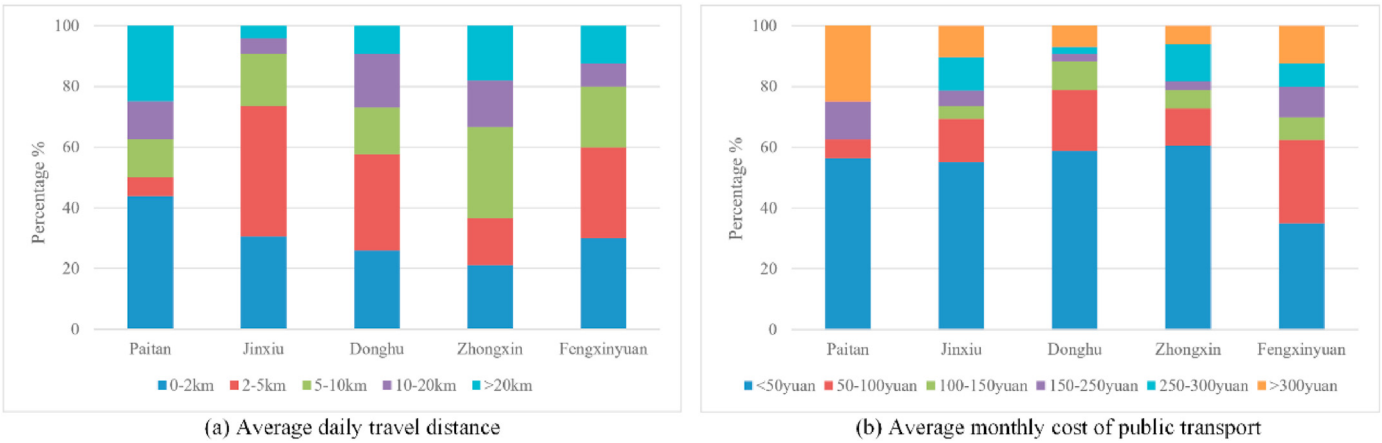
When it comes to the expense of staple food, except Fengxinyuan, significant differences could be observed between Donghu and other three communities. The average costs of the respondents in Donghu in buying staple food and meat were less than other four communities while Jinxiu was higher than other four communities, which further reflects the high living standard of residents in Jinxiu.

#### 4.1.5. Energy consumption in different communities

As shown in Fig. 8, natural gas and electricity were the main sources of energy used in household life, and more than 56% of the respondents used these two types of energy in daily life. Since the environmental problems have been becoming more and more severe, solar power, as a kind of renewable, clean, and pollution-free energy, has been praised as the most hopeful energy in the 21st century. Nevertheless, the proportion of solar energy consumed in the households of the respondents was lower, with only 7.6%. The development of green energy is an inevitable choice for social development, which plays an irreplaceable role in alleviating the shortage of traditional energy and improving the energy consumption structure. In recent years, in order to promote the healthy and sustainable development of the solar power industry, the state has issued a series of relevant development plans. The 13th Five-Year Plan for energy development pointed out that non-fossil energy should be promoted to develop, and renewable resources such as wind power and solar energy should be steadily developed (NEA, 2016). The development of


(a) The proportion of respondents buying and renting houses (b) Family housing area

**Fig. 4.** The respondents' housing Conditions.




(a) Average daily travel distance (b) Average monthly cost of public transport

**Fig. 5.** Respondents' traffic mode and consumption.

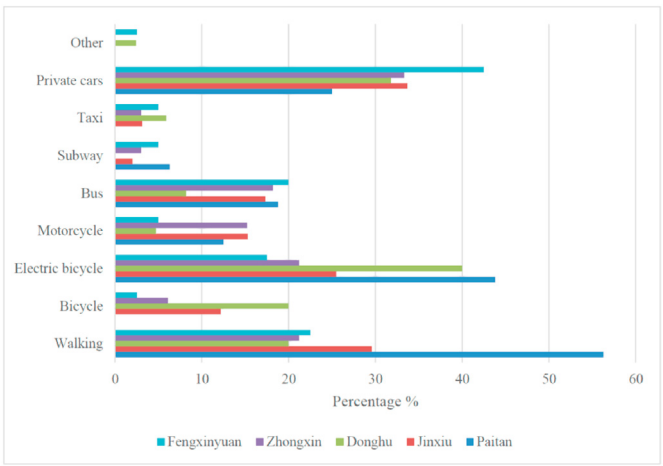



**Fig. 6.** The most common way for families to travel.

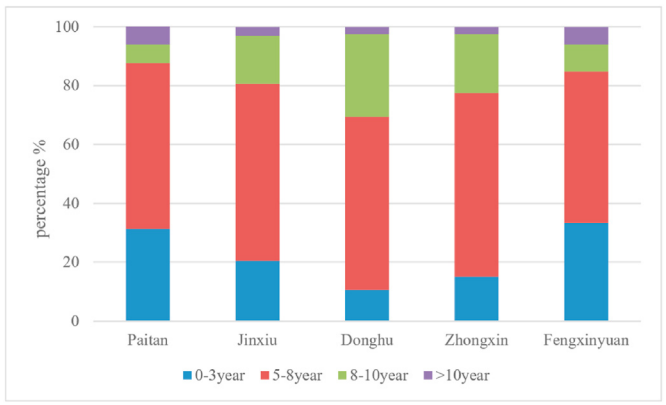



**Fig. 7.** Average life of household durable goods.

advanced biofuels plays an important role on the way to the low-carbon energy system (Drews et al., 2020). Thus, Zengcheng district should take some positive measures to implement the use of new energy for households.

As shown in Fig. 9(a), the electricity consumption per month of Jinxiu was the highest (The proportion of electricity consumption under 50kwh per month was the lowest and the proportion more than 200kwh was the highest), while those in the nearby Donghu consumed the least. There were significant differences between the two communities. Fig. 9(b) showed the average monthly household water consumption, Jinxiu was higher than the other four communities, followed by Fengxinyuan and Donghu, while Paitan community had the least consumption. Respondents in Jinxiu had the smallest proportion of monthly water consumption below 10t, and respondents in Fengxinyuan had the largest proportion of household average monthly water consumption above 50t. About 94% of the respondents in Paitan community used less than 30t of

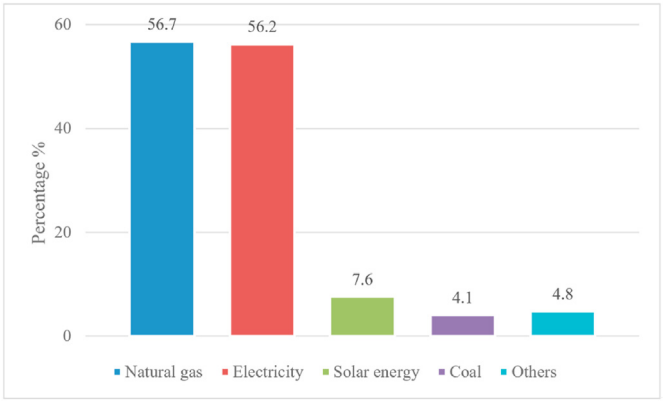



**Fig. 8.** The main energy consumption in family life.

water per month.

As can be seen from Table 2, the amount of coal used once year by the respondents in the five communities was not large, and the average annual usage was below 1ton. Fig. 9(c) showed that Zhongxin had the highest monthly household coal use, with more than 50 percent of respondents using coal in their daily lives. The coal consumption in Jinxiu and Fengxinyuan had significant differences with Zhongxin.

As shown in Fig. 9(d), in terms of respondents' household monthly natural gas expenditure, the residents in Jinxiu cost more than others, and the proportion of the average monthly expenditure above 100 yuan was the largest. The residents in Donghu had the least consumption, with the proportion of spending less than 50 yuan per month was the lowest. Liu et al. (2018) indicated that the natural gas price and the household income all had significant impact on the natural gas consumption, so the government could adjust the price of natural gas and increase the residents' income to promote the residents choose natural gas as an alternative to other energy. Fig. 9(e) showed the average monthly gasoline expenditure. The respondents in Jinxiu took the highest proportion, about 50% of respondents spent more than 500 yuan per month on average, and the households spending more than 1000 yuan per month accounted for a higher proportion than the other communities. The proportion of households spending less than 300 yuan per month was the highest in Donghu, while the proportion of households spending less than 100 yuan was the highest in Paitan community.

As shown in Fig. 16(f), the residents in Zhongxin and Paitan had the lowest times of eating out per month, and approximately 80% of respondents in these two communities eat out less than 4 times every month. Respondents in Jinxiu had the highest times of meals out, with the proportion of respondents eating out more than 7 times per month higher than that of the other communities.

### 4.2. *Factors influencing carbon emissions of household energy consumption*

#### 4.2.1. *Household demographic information*

The Number of family members, educational level, occupation and physical condition all had significant impacts on Ces-he, Ces-hc, Ces-hg and CEs-HE (Table 2). Wen and Cao (2020) also indicated that the residents' economic level, the increase of population, and employment all have a certain degree of promoting the carbon emissions of households. In terms of total carbon emissions, the family size had the greatest effect, followed by educational level. The larger the number of households and the higher educational level, the more carbon emissions produced; the worse the physical health, the more carbon emissions generated. It is relatively easy for highly educated respondents to accept low-carbon knowledge, so the government can strengthen the guidance and promotion of low-carbon life concept.

#### 4.2.2. *Main expenditure items*

As shown in Table 3, in terms of the total carbon emissions and the carbon emissions caused by the four energy sources, the proportion of food consumption, residence consumption, and entertainment consumption in total consumption all had impact effects. Specifically, among the three influencing factors, the food consumption proportion in the total consumption had the largest impact on the CEs-HE. Jinxiu had the largest food consumption proportion, and so its total carbon emissions were the largest. The proportion of educational and entertainment has the least impact on the total carbon emissions. Dai et al. (2012) indicated that when the household spending shifts from transportation and physical goods to service-oriented goods, the energy consumption and carbon emissions could be significantly reduced. Therefore, policy makers should guide the consumers to choose energy-saving and service-oriented goods consciously in their daily lives, and shift their consumption pattern to a more sustainable direction.

#### 4.2.3. *Housing conditions*

Among the influence factors, the geographical location and the area of houses had greater impacts than other factors on CEs-HE, Ces-he, Ces-hn and Ces-hg, respectively. Specifically, the larger the area, the more carbon emissions produced. Since Jinxiu had the largest housing area, its average monthly CEs-HE, Ces-he, Ces-hn and Ces-hg were all higher than the other four communities (Table 4). The government should guide families to choose a reasonable housing area, and do not blindly pursue large housing area, especially for the household in Jinxiu community. Similar to previous literatures, such as Damette et al. (2018), this study find that the housing ownership also had significant impact on the carbon emissions, specifically, if the householder is the homeowner, the carbon emssions will be decreased.

#### 4.2.4. *Daily travelling*

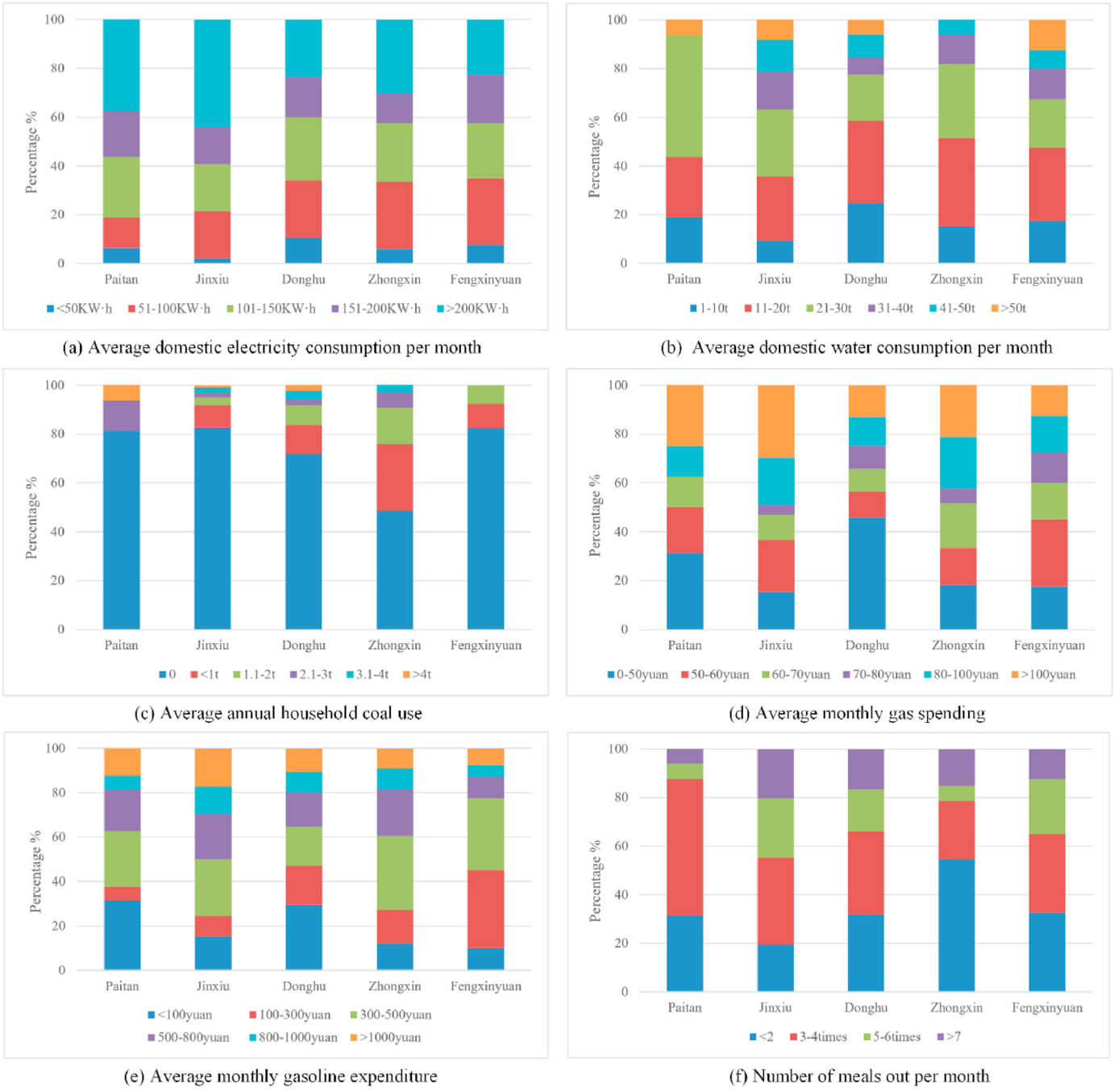
Daily travel distance, travel time and the cost for cars all had significant impacts on the Ces-he, Ces-hn, Ces-hg and CEs-HE (Table 5). The longer the daily travel time, the farther the travel distance and the more the cost for the car, the more Ces-he, Ces-hn, Ces-hg and CEs-HE were produced. When it comes to the Ces-hc, daily travel distance and the cost for cars had significant effects on it. To some extent, the high car cost represents high consumption level and leads to large energy consumption. Guiding the residents to travel and consume nearby will play a certain role in reducing carbon emissions. Yu et al. (2012) indicated that adding bus lines and leisure facilities in the neighborhood of the community can greatly promote the residents' energy-efficient consumption behavior. So the government could strengthen the construction of infrastructures in this region, such as the parks and public transportation.

#### 4.2.5. *Family life habits*

The life of household durable goods, the consumption of electric, coal natural gas and gasoline, the times of cooking at home per week and eating out per month all had significant effects on CEs-HE (Table 6). According to Wen and Cao (2020)), the increase of household appliances contributed to the growth of carbon emissions. The specific impacts in this study were shown in the following aspects: the greater the consumption of electricity, the greater the total carbon emissions; when the household durable goods' service life exceed a certain range, carbon emissions cannot be reduced, but be increased; the more times cooking at home and eating out, the more carbon emissions produced. When it comes to the Ces-he, the same trend could be found.

The consumption of electricity, natural gas and gasoline were the largest in Jinxiu, and the corresponding Ces-he, Ces-hn, Ces-hg were also the largest correspondingly. The electricity consumption and natural gas consumption in Donghu community were the lowest, so the corresponding Ces-he and Ces-hn were also the lowest. The household in Xintang consumed the least amount of gasoline and produced the least Ces-hg among the five communities.

Reducing energy use is an effective way to decrease carbon emissions.




(a) Average domestic electricity consumption per month

(b) Average domestic water consumption per month

(c) Average annual household coal use

(d) Average monthly gas spending

(e) Average monthly gasoline expenditure

(f) Number of meals out per month

**Fig. 9.** Energy consumption in different communities.

**Table 2**
The influence of household demographic information on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Fam | 0.440** | 0.015 | 0.337** | 0.019 | 0.339** | 0.030 | 0.313** | 0.026 | 0.429** | 0.018 |
| Edu | 0.214** | 0.020 | 0.166** | 0.024 | 0.188 | 0.039 | 0.366** | 0.034 | 0.201** | 0.023 |
| Occ | 0.156** | 0.017 | 0.203** | 0.021 | 0.001 | 0.034 | 0.133* | 0.030 | 0.158** | 0.021 |
| Phy | 0.205** | 0.039 | 0.251** | 0.047 | −0.023 | 0.077 | 0.142** | 0.067 | 0.198** | 0.046 |

Coe: typical coefficient; Ste: standard error; Fam: Family members; Edu: Educational level; Occ: Occupation; Phy: Physical condition.
*$p < 0.05$; **$p < 0.01$.

For the perspective of energy saving, it is very important for the government to implement some measures that can guide the residents' energy saving consumption behavior (Wu et al., 2019b). In particular, the household in Jinxiu should be strengthened to guide energy-efficient

**Table 3**
The impact of the proportion of primary consumption in total consumption on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Fct | 0.595** | 0.027 | 0.419** | 0.034 | 0.232* | 0.051 | 0.491** | 0.046 | 0.569** | 0.031 |
| Rct | 0.214** | 0.024 | 0.279** | 0.030 | 0.160 | 0.046 | 0.171** | 0.042 | 0.259** | 0.028 |
| Ect | 0.165** | 0.031 | 0.237** | 0.039 | 0.122 | 0.059 | 0.274** | 0.053 | 0.176** | 0.036 |

Fct: The proportion of food consumption in total consumption; Rct: The proportion of residence consumption in total consumption; Ect: The proportion of education and entertainment consumption in total consumption.
*p < 0.05; **p < 0.01.

**Table 4**
The impacts of housing conditions on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Own | 0.266** | 0.038 | 0.002 | 0.049 | 0.385** | 0.086 | −0.041 | 0.073 | 0.234** | 0.045 |
| Loc | 0.309** | 0.027 | 0.607** | 0.035 | 0.122 | 0.062 | 0.486** | 0.053 | 0.356** | 0.032 |
| Inh | 0.135** | 0.041 | 0.108* | 0.053 | 0.403** | 0.094 | 0.187** | 0.080 | 0.174** | 0.048 |
| Are | 0.316** | 0.017 | 0.242** | 0.022 | −0.388** | 0.039 | 0.317** | 0.033 | 0.262** | 0.020 |

Hoo: Housing ownership; Loc: Geographical location of the house; Inh: Inhabiting information; Are: Area of the house.
*p < 0.05; **p < 0.01.

**Table 5**
The impacts of daily travelling on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Trd | 0.290** | 0.031 | 0.228** | 0.027 | 0.314** | 0.039 | 0.084* | 0.029 | 0.234** | 0.045 |
| Trt | 0.379** | 0.029 | 0.274** | 0.025 | −0.119 | 0.035 | 0.246** | 0.026 | 0.356** | 0.032 |
| Coc | 0.314** | 0.027 | 0.437** | 0.023 | 0.314** | 0.033 | 0.653** | 0.024 | 0.174** | 0.048 |

Trd: Daily travel distance; Trt: Daily travel time; Coc: The cost for the car per month.
*p < 0.05; **p < 0.01.

**Table 6**
The impacts of family life habits on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Ser | 0.171** | 0.017 | 0.142** | 0.021 | 0.028 | 0.023 | 0.150** | 0.022 | 0.186** | 0.023 |
| Coe | 0.497** | 0.014 | 0.046 | 0.016 | 0.004 | 0.018 | 0.053 | 0.017 | 0.298** | 0.018 |
| Cow | 0.009 | 0.014 | 0.003 | 0.017 | −0.046 | 0.018 | −0.008 | 0.018 | 0.002 | 0.019 |
| Coc | 0.040** | 0.015 | 0.013 | 0.018 | 0.887** | 0.020 | 0.015 | 0.019 | 0.088** | 0.020 |
| Con | 0.045** | 0.009 | 0.609** | 0.011 | −0.037 | 0.012 | 0.021 | 0.011 | 0.068** | 0.012 |
| Cog | −0.010 | 0.011 | 0.001 | 0.013 | 0.051 | 0.015 | 0.698** | 0.014 | 0.117** | 0.015 |
| Coh | 0.167** | 0.013 | 0.107** | 0.015 | 0.006 | 0.017 | 0.029 | 0.016 | 0.180** | 0.017 |
| Eao | 0.142** | 0.016 | 0.119** | 0.019 | 0.099* | 0.021 | 0.078** | 0.020 | 0.160** | 0.021 |

Ser: The service life of household durable goods; Coe: The consumption of electric; Cow: The consumption of water; Coc: The consumption of coal; Con: The consumption of natural gas; Cog: The consumption of gasoline; Coh: The times of cooking at home per week; Eao: The times of eating out per month.
*p < 0.05; **p < 0.01.

consumption. The use of family cars should be transformed from high fuel consumption and emission to lower fuel consumption and emission, such as electric cars. Ohler et al. (2020) found that the energy star refrigerators could reduce electricity use significantly and the LCD TV could increase the electricity consumption. So choosing energy-saving and environment-friendly electrical appliances should be suggested, and the service life of household appliances should not exceed a certain number of years. The proportion of durable household goods in Paitan and Zhongxin community over 10 years were higher than other three communities, which should be improved. In terms of diet, "green food" production can be comprehensively developed, and the consumption of primary foods and less dining out can be encouraged. Since the pattern of household food consumption in China is dominated by foods derived from plants (Song et al., 2015), it will be easy to advocate for "green food".

#### 4.2.6. Environmental awareness

The environmental preferences affect residents' energy choices, specifically, when the residents consider that the environment is very important, they are more likely to choose clean energy (Damette et al., 2018). As shown in Table 7, the satisfaction with garbage disposal and environment, daily ways of disposing household waste, awareness of environmental changes, and the most concerned problem about the environment all had significant effects on carbon emissions. Among all the influence factors, the way garbage was handled and the degree of satisfaction with garbage disposal had the greatest impacts. Specifically, the higher the satisfaction and the more possibility that household could classify waste in detail, the lower carbon emissions led to.

**Table 7**
The impacts of environmental awareness on carbon emissions.

| | Ces-he | | Ces-hn | | Ces-hc | | Ces-hg | | CEs-HE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste | Coe | Ste |
| Sag | 0.243** | 0.030 | 0.130 | 0.034 | 0.673** | 0.056 | 0.255** | 0.049 | 0.268** | 0.034 |
| Was | −0.359** | 0.033 | −0.208** | 0.038 | 0.100 | 0.062 | −0.399** | 0.057 | −0.345** | 0.038 |
| Enc | 0.106** | 0.039 | 0.099 | 0.044 | 0.313** | 0.074 | 0.164** | 0.065 | 0.130** | 0.045 |
| Con | 0.129** | 0.017 | 0.246** | 0.019 | −0.209* | 0.032 | 0.023 | 0.028 | 0.107** | 0.020 |
| Sae | 0.174** | 0.034 | 0.283** | 0.039 | −0.373* | 0.065 | 0.105 | 0.057 | 0.164** | 0.039 |

Sag: Satisfaction with garbage disposal; Was: waste disposal methods; Enc: Environmental changes in recent years; Con: Most concerned about the environment; Sae: Satisfaction of environment management.
*$p < 0.05$; **$p < 0.01$.

Strengthen the construction of urban infrastructure, improve the satisfaction of residents, increase the publicity of garbage classification, encourage residents to do detailed garbage classification (especially the households in Paitan and Xintang) can reduce carbon emissions effectively. In the aspect of waste treatment, the satisfaction of Zhongxin and Paitan should be enhanced, while in terms of environmental protection, the family satisfaction of Zhongxin and Xintang should be enhanced.

## 5. Conclusions

In this paper, questionnaire surveys were administered to investigate the household consumption characteristics at community scale in Zengcheng. The statistical analyses indicated that respondents from different communities had significant differences in their residential consumption, housing conditions, daily travel distance, public transport charge, household durable goods service life, monthly staple food consumption, and monthly energy consumption, respectively. Specifically, among the five selected communities, the respondents in Jinxiu had the largest proportion of commercial housing with purchased housing, the largest housing area, the most consumption of electricity, domestic water, natural gas and gasoline. Comparatively, Donghu, which is also located in the optimized development of cultural industrial areas, had significant differences with Jinxiu in the energy for family life. It reflected that the household in Donghu had better low-carbon awareness. In addition, the low purchased housing proportion, low percentage of car ownership, high public transport costs, high monthly average coal consumption, and low frequency of eating out in Paitan indicated that the living standard was lower than that of the other communities. The reasons for the above consumption characteristics were somewhere related to the urban development planning of Zengcheng District. The restricted development zones in the north limited commercial development, resulting in low income and low living standards for the local residents. The optimized development area in the central area tends to follow the economic and environmental friendly the path, which mainly developed the cultural and conference leisure industry and promoted the improvement of the residents' living standard. However, the consumption characteristics of the two communities in this area were significantly different, indicating that the residents' awareness of energy conservation and emission reduction in Jinxiu was still relatively weak and needs to be strengthened.

The average CEs-HE of each household were 410.6 $kgCO_2$ per month. Jinxiu had the highest average monthly CEs-HE (451.4 $kgCO_2$), while Fengxinyuan had the lowest CEs-HE (340.7632 Kg $kgCO_2$). The Household demographic information, main expenditure items, housing conditions, daily travelling, family life habits and residents' environmental awareness all had significant impacts on CEs-HE. As a basic unit of a city, community is the institute where the management indicators, methods and policies are most likely to be operated and implemented. By comparing the consumption characteristics and the CEs-HE in the five communities, and analyzing the main influencing factors of CEs-HE, governments can take corresponding measures to reduce carbon emissions in different regions. This study can provide some valuable information for household energy conservation and emission reduction measures to establish low-carbon community construction and explore the road of urban sustainable development.

## Declaration of competing interest

We declare that we 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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## Appendix

### *I. Notes of the Superscript in Table 1*

| Superscript | Value | Meaning of numerical value |
|---|---|---|
| 1 | 1–4 | 0–15%, 15%–30%, 30%–60%, more than 60% |
| 2 | 1–5 | 0, 0–30%, 30%–60%, 60%–80%, more than 80% |
| 3 | 1–5 | 0–10%, 10%–30%, 30%–60%, 60%–80%, more than 80% |
| 4 | 1–2 | The house is commercial housing or not |
| 5 | 1–2 | The house is purchased or rented |
| 6 | 1–2 | Live alone or with parents |
| 7 | 1–5 | Less than 60$m^2$, 60–80$m^2$, 80–100$m^2$, 100–120$m^2$, more than 120 $m^2$ |
| 8 | 1–5 | Less than 2 km, 2–5 km, 5–10 km, 10–20 km, more than 20 km |
| 9 | 1–5 | Less than 15 min, 15–30 min, 30–45 min,45–60 min, more than 60 min |
| 10 | 1–6 | Less than 50 yuan, 50–100 yuan, 100–150 yuan, 150–250 yuan, 250–350 yuan, more than 350 yuan |
| 11 | 1–5 | Less than 200 yuan, 200–500 yuan, 500–800 yuan, 800–1000 yuan, more than 1000 yuan |

(*continued on next column*)

(*continued*)

| Superscript | Value | Meaning of numerical value |
|---|---|---|
| 12 | 1–4 | Less than 3 years, 5–8 years, 8–10 years, more than 10 years |
| 13 | 1–7 | Less than 100 yuan, 101–150 yuan, 151–200 yuan, 201–250 yuan, more than 250 yuan |
| 14 | 1–6 | Less than 100 yuan, 101–200 yuan, 201–400 yuan, 401–600 yuan, 601–800 yuan, 801–1000 yuan, more than 1000 yuan |
| 15 | 1–5 | Less than 50 kw·h, 51–100 kw·h, 100–150 kw·h, 151–200 kw·h, more than 200 kw·h |
| 16 | 1–6 | Less than 10 t, 11–20 t, 21–30 t, 31–40 t, 41–50 t, more than 50 t. |
| 17 | 1–5 | Less than 1 t, 1.1–2 t, 2.1–3 t, 3.1–4 t, more than 4 t |
| 18 | 1–6 | Less than 50 yuan, 50–60 yuan, 60–70 yuan, 70–80 yuan, 80–100 yuan, more than 100yuan |
| 19 | 1–6 | Less than 100 yuan, 100–300 yuan, 300–500 yuan, 500–800 yuan, 800–1000 yuan, more than 1000 yuan |
| 20 | 1–4 | 1-3 times, 4-6times, 7–9 times, more than 10 times |
| 21 | 1–4 | Less than 2 times, 2-3times, 3–4 times, more than 4 times |
| 22 | 1–5 | Very satisfied, relatively satisfied, satisfied, dissatisfied, and don't care |
| 23 | 1–4 | Discarded casually, simple classification, detailed classification, other ways |
| 24 | 1–4 | Getting better, not changing much, getting worse, don't care |
| 25 | 1–5 | Water pollution, the waste pollution of industry, farmland and soil pollution, pollution from the living of the inhabitants, other types of pollution |
| 26 | 1–5 | Very satisfied, relatively satisfied, satisfied, dissatisfied, and don't care |

***II. A questionnaire on household consumption***

Part 1: Respondents' demographic information (occupation, educational level, physical condition).

1) **Your family size _.**
2) **Your occupation _**

1. Public servant 2. Company employee 3. Businessman 4. Peasant 5. Other.

3) **Your educational level _**

1. Middle school or below 2. High school 3. Junior college.
4. Undergraduate 5. Graduate degree or above.

4) **Your Physical condition_**

1. Very health 2. Healthy, occasionally ill 3. Long-term illness, does not affect normal work 4. Chronic illness and affects normal life.

Part 2: The proportion of respondents' various consumption in total consumption (food consumption, residential consumption, education and entertainment consumption).

5) **The proportion of food consumption in total consumption_**

1. Less than 15% 2.15%–30% 3.30%–60% 4. More than 60%

6) **The proportion of residential consumption in total consumption_**

1.0 2.0–30% 3.30%–60% 4.60%–80% 5. More than 80%

7) **The proportion of education and entertainment consumption in total consumption_**

1. Less than 15% 2.15%–30% 3.30%–60% 4.60%–80% 5. More than 80%

Part 3: Respondents' housing Conditions (commodity house or not, housing ownership, inhabiting information, housing area and housing community).

8) **Your house is commercial housing or not ___**

1. Yes 2. No.

9) **The house is purchased or rented**

1. Purchased 2. Rented.

10) **Your residence status_**

1. Live alone 2. Live with parents.

11) **The area of your house_.**

1. Less than 60 $m^2$ 2.60–80 $m^2$ 3.80–100 $m^2$ 4.100–120 $m^2$ 5. more than 120 $m.^2$

12) **Where do you live__.**

1. Paitan community 2. Jinxiu community 3. Donghu community.
4. Zhongxin community 5. Fengxinyuan community.

Part 4: Respondents' traffic mode and consumption (daily travel distance, transportation tools currently owned by the family, daily trip time, Monthly expenses for public transportation and private cars).

13) **Your daily travel distance_.**

1. Less than 2 km 2.2–5 km 3.5–10 km 4.10–20 km 5. More than 20 km.

14) **Which transportation do you use most often when you travel?**

1. Walking 2. Bicycle 3. Electric bicycle 4. Motorcycle 5. Bus.
6. Subway 7. Taxi 8. Private cars 9. Other ways.

15) **Your daily trip time__.**

1. Less than 15 min 2.15–30 min 3.30–45 min 4.45–60 min 5. More than 60 min.

16) **The monthly cost of public transport__**

1. Less than 50 yuan 2.50–100 yuan 3.100–150 yuan 4.150–250 yuan.
5.250–350 yuan 6. More than 350 yuan.

17) **The monthly cost of private cars**

1. Less than 200 yuan 2.200–500 yuan 3.500–800 yuan.
4.800-1000yuan 5. More than 1000 yuan.

Part 5: Daily necessities consumption (the service life of household durable goods, average meat cost per month, monthly average cost of staple food).

18) **The average service life of household durable goods (TV set, washing machine, refrigerator, air conditioner, computer, etc.) in your home is about_.**

1. Less than 3 years 2.5–8 years 3.8–10 years 4. More than 10 years.

19) **The monthly consumption of staple food__.**

1. Less than 100 yuan 2.101–150 yuan 3.151–200 yuan.
4.201–250 yuan 5. More than 250 yuan.

20) **The monthly consumption of meat__.**

1. Less than 100 yuan 2.101–200 yuan 3.201–400 yuan 4.401–600 yuan.
5.601–800 yuan 6.801–1000 yuan 7. More than 1000 yuan.

Part 6: The main energy consumption in family life and monthly energy consumption (electricity, domestic water, coal, natural gas, gasoline, cooking at home per week, number of meals out).

21) **The Average monthly household electricity consumption__.**

1. Less than 50 kw·h 2.51–100 kw·h 3.101–150 kw·h.
4.151–200 kw·h 5. More than 200 kw·h.

22) **The Average monthly domestic water consumption__.**

1. Less than 10 t 2.11–20 t 3.21–30 t 4.31–40 t 5.41–50 t 6. More than 50 t.

23) **What are the main types of energy consumed in household life (Multiple choice question) __.**

1. Natural gas 2. Coal 3. Electricity 4. Solar energy 5. Othere

24) **The annual coal consumption__.**

1. Less than 1 t 2.1.1–2 t 3.2.1–3 t 4.3.1–4 t 5. More than 4 t.

25) **The Average monthly natural gas cost__.**

1. Less than 50 yuan 2.50–60 yuan 3.60–70 yuan 4.70–80 yuan.
5.80–100 yuan 6. More than 100yuan.

26) **The Average monthly gasoline consumption__.**

1. Less than 100 yuan 2.100–300 yuan 3.300–500 yuan 4.500–800 yuan.
5.800–1000 yuan 6. More than 1000 yuan.

27) **The number of times you cook at home per week___.**

1.1–3 times 2.4-6times 3.7–9 times 4. More than 10 times.

28) **The number of times you eat out per month___.**

1. Less than 2 times 2.2-3times 3.3–4 times 4. More than 4 times.

Part 7: Environmental perception (satisfaction with garbage disposal, waste disposal methods, awareness of environmental changes, most concerned environmental issues, satisfaction with environmental protection).

29) **Are you satisfied with the garbage disposal in this region?__**

1. Very satisfied 2. Relatively satisfied 3. Satisfied 4. Dissatisfied 5. Don't care.

30) **The waste disposal methods you taken in your daily life__.**

1. Discarded casually 2. Simple classification 3. Detailed classification 4. Other ways.

31) **In the past 10 years, the changing trend of the environment in this region is_.**

1. Getting better 2. Not changing much 3. Getting worse 4. Don't care.

32) **What is your most concerned environmental issues in this region?__.**

1. Water pollution 2. The waste pollution of industry 3. Farmland and soil pollution, 3. Pollution from the living of the inhabitants 4. Other types of pollution.

33) **Are you satisfied with the ecological environment management and construction in this region**

1. Very satisfied 2. Relatively satisfied 3. Satisfied 4. Dissatisfied 5. Don't care.

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