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A full permutation polygon synthetic indicator (FPPSI) approach for measuring and evaluating city prosperity: case study in Da Nang City, Vietnam

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Abstract. Economic growth has dominated development strategies and goals for many years, but prosperity encompasses more than that. In 2013, UN-Habitat proposed the City Prosperity Initiative (CPI) as a tool to quantify cities' prosperity and sustainable development. The CPI is accompanied by six essential components with 62 indicators associated with the urban settlement, incorporating productivity, infrastructure development, quality of life, social inclusion, environmental sustainability, and urban governance and legislation. The research aims to use the indicators of CPI and adopted the Full Permutation Polygon Synthetic Indicator method to measure and evaluate the level of prosperity of Da Nang City of Vietnam with data from 2004 to 2019. According to the findings of our study, the value of a synthetic indicator for the prosperity of Da Nang City increased, from 0.34 in 2004 to 0.36 in 2009, 0.43 in 2014, and 0.45 in 2019, which indicates a moderate level of wealth. On the one hand, Da Nang City has high levels of quality of life, equity and social inclusion, and urban governance and legislation. However, the city still has modest determinants of prosperity in terms of the environment, productivity and infrastructure. The Full Permutation Polygon Synthetic Indicator technique provides a comprehensive solution that illustrates the system integration idea. As a result, the proposed methodology offers a potential foundation for decision-making to promote sustainable urban development strategies and assess the effectiveness of these actions.

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1. Introduction

With almost half of the world's population residing in cities, the population's future is urban (United Nations, 2018). Cities have risen to prominence as drivers of productivity, technology, infrastructure development, and institutional systems that help improve equity, social inclusion, and overall quality of life (UN Habitat, 2016). However, urban sprawl, pollution, and environmental degradation can be exacerbated by unplanned or poorly managed urban development, in combination with unsustainable production and consumption practices and a lack of capability of governmental institutions to manage urbanization (Feng Li et al., 2009). The wealth created by cities has not been divided equally. A significant portion of the urban population continues to be excluded from the benefits that cities generate. *The State of the World's Cities Report*, published in 2013, proposed a concept of prosperity beyond the concept of economic growth that has dominated development strategy and agendas for many years. Prosperity looks at how cities may create and equitably divide the advantages and opportunities that come with wealth, assuring economic well-being, social cohesion, environmental sustainability, and a higher overall quality of life (UN Habitat, 2013). UN Habitat also developed a tool to measure the sustainability of cities. This tool is known as the City Prosperity Initiative (CPI), accompanied by a conceptual matrix of crucial components with 62 indicators (UN Habitat, 2016; Arbab, 2017).

Vietnam is undergoing rapid urbanization and industrialization accompanied by a swiftly rising GDP, rapidly developing urban infrastructures, and significant changes in the quality of life in cities. Building an efficient, healthy and civilized urban society encompassing livable human settlements and regional ecological security has become a global priority for governments and organizations and is gradually becoming a national goal in Vietnam. The Vietnamese government has already begun to propose people-oriented development strategies for constructing sustainable and harmonious cities (The Socialist Republic of Vietnam, 2015; The Socialist Republic of Vietnam, 2018). Establishing assessment indicators and methodologies has become an urgent concern in Vietnam to provide objective evidence for evaluating the progress towards urban sustainable development achieved. In 2014, the CPI of UN Habitat was first introduced in Vietnam with many scientific seminars and training courses from the Ministry of Construction. In 2016, Hanoi, Ho Chi Minh City, Da Nang City, Hai Phong, and Can Tho, five of Vietnam's most prominent cities directly under the Central Government, agreed to implement CPI. However, Vietnam currently only has Can Tho to develop the CPI for itself (Institute of Socio-Economics of Can Tho City, 2019).

The research aims to apply indicators of CPI and built a comprehensive index by using the Full Permutation Polygon Synthetic Indicator (FPPSI) method to measure and evaluate the level of prosperity of Da Nang City with the temporal scope of data in the period 2004–2019. The assessment results are essential bases for city leaders to comprehensively review the urban development process and plan appropriate policies to promote sustainable development.

2. Study area

Da Nang City is one of Vietnam's most important port cities. It is located on the coast of the East Sea in the middle of Vietnam, known as the most livable, dynamic, friendly, and peaceful city. It is administered by the central government as one of the direct-controlled municipalities and the largest city in the Central area. Da Nang City serves as the region's economic, commercial, and educational hub. It also serves as a transportation hub, thanks to its placement on National Route 1A and the North–South Railway, and it lies at one end of the East–West Economic Corridor, an economic corridor connecting Vietnam with Laos, Thailand, and Myanmar. Furthermore, Da Nang City additionally benefits from being the center for three UNESCO World Heritage Sites: the Hue Citadel in Thua Thien-Hue province, Hoi An historic town, and My Son Sanctuary in Quang Nam province.

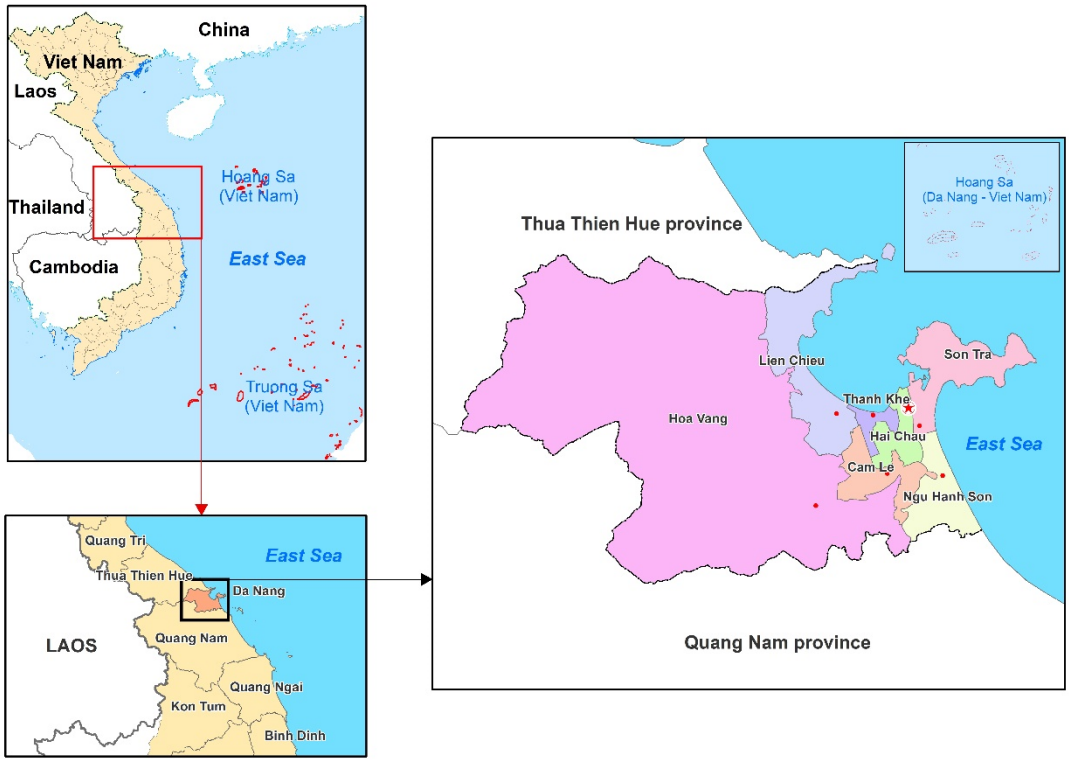

Fig. 1. Location of study area (Da Nang City, Vietnam)
Source: own elaboration

Da Nang City is bounded to the north by Thua Thien Hue province, to the west and south by Quang Nam province, and to the east by the East Sea. Before 1997, the city was the territory of the Quang Nam–Da Nang province. On January 1, 1997, it was withdrawn from Quang Nam Province and became one of Vietnam's five autonomous (centrally-controlled) municipalities. With a population of 1,141 thousand people in 2019, the city covers an area of 1284.4 km^2. It comprises six urban districts (Hai Chau, Ngu Hanh Son, Thanh Khe, Son Tra, Lien Chieu, Cam Le) and Hoa Vang rural district, the Hoang Sa island district (see Fig. 1). Currently, Da Nang City has the highest proportion of urban population among the provinces in Vietnam, with nearly 90 percent in 2020, while the average urban population rate of the whole country is only 37.3 percent (General Statistics Office, 2021).

The climate of Da Nang City is characteristic of the tropical monsoon season. It maintains a generally constant temperature with little change. Its climate is divided into two seasons: a rainy season from August to December and a dry season from January to July, with rainfall concentrating mainly between September and December. Every year, 1–2 typhoons and 1–2 significant flooding spells hit this area directly or indirectly (Vu Tu Lap, 2012). The average humidity is 83.4 percent, and the average temperature is around 26 °C. The highest temperatures are 28–30°C in June, July, and August, while the lowest temperatures are 18–23°C in December, January, and February. The average annual rainfall is 2,505 mm, with October and November being the wettest months. This area's geography ranges from flat to hilly, with elevations ranging from 0 to 1700 m above mean sea level (Da Nang City Statistics Office, 2021).

Da Nang City is Central Vietnam's most significant manufacturing city. Its GDP *per capita* in 2019 was 4171 USD, making it one of the wealthiest in Vietnam (after Ho Chi Minh City, Hanoi, Binh Duong Province, and Dong Nai Province) (Da Nang City Statistics Office, 2021; General Statistics Office, 2021). Da Nang City is one of the municipalities that has remained at the top of the Provincial Competitiveness Index rankings for many years, mainly benefiting from good performance in labor training, transparency, proactive provincial leadership, and low entry costs (Malesky et al., 2020). The economic structure of the city is shifting to a "service–industry–agriculture" paradigm. The service sector, including tourism, still accounts for the highest proportion of the economic system of this coastal city. In 2020, the service sector was estimated

to reach 64.56%; the industry-construction sector was 22.32%; the agricultural sector was estimated at 1.72% in the city's economic composition (Da Nang City Statistics Office, 2021).

3. Methodology

3.1. An indicator system for City Prosperity of Da Nang City

For a prosperous life, the provision of primary material and immaterial needs is crucial. However, prosperity is more than fulfilling basic needs, and accordingly, urban prosperity is more than combating metropolitan problems (Sasaki, 2014). Prosperity is a social construct that manifests itself via human actions. It is a more significant, broader concept concerned with clear policies and well-balanced, harmonic growth in a fair and just environment (Jackson, 2009; UN Habitat, 2013). In 2013, UN Habitat developed an indicator system to assess the sustainability of cities known as the City Prosperity Initiative (CPI), which argues for the need to move toward measuring the broad conception of human and societal well-being in terms of sustainability (UN Habitat, 2015; Wong, 2015). The CPI was accompanied by six key dimensions with 62 indicators, as follows:

- Productivity (8 indicators): City Product *per capita* (USD,PPP), Old Age Dependency Ratio (%), Mean Household Income (USD,PPP), Economic Density (Million USD/km^2), Economic Specialization (Constant), Unemployment Rate (%), Employment to Population Ratio (%), Informal Employment (%).
- Productivity (8 indicators): City Product *per capita* (USD,PPP), Old Age Dependency Ratio (%), Mean Household Income (USD,PPP), Economic Density (Million USD/km^2), Economic Specialization (Constant), Unemployment Rate (%), Employment to Population Ratio (%), Informal Employment (%).
- Infrastructure development (19 indicators): Improved Shelter (%), Access to Improved Water (%), Access to Improved Sanitation (%), Access to Electricity (%), Sufficient Living Area (%), Population Density (people/km^2), Physician Density (per 1000 population), Number of Public Libraries (per 100 000 population), Internet Access (%), Home Computer Access (%), Average Broadband Speed (kpbs), Use of Public Transport (%), Average Daily Travel Time (minutes), Length of Mass Transport Network (km/million population), Traffic Fatalities (fatalities per 100,000 people), Affordability of Transport (%), Street Intersection Density (intersections/km^2), Street Density (km/km^2), Land Allocated to Streets (%).
- Quality of life (12 indicators): Life Expectancy at Birth (year), Under-Five Mortality Rate (‰), Vaccination Coverage (%), Maternal Mortality (mother per 100,000 live births), Literacy Rate (%), Mean years of Schooling (year), Early Childhood Education (%), Net enrollment rate in higher education (%), Homicide rate (Homicides per 100,000 inhabitants), Theft rate (Thefts per 100,000 inhabitants), Accessibility to Open Public Areas (%), Green Area *per capita* (m2/person).
- Equity and social inclusion (8 indicators): Gini Coefficient (constant), Poverty Rate (%), Slums Households (%), Youth Unemployment (%), Equitable Secondary School Enrollment (Dimensionless), Women in Local Government (%), Women in Local Work Force (%), Land Use Mix (Dimensionless).
- Environmental sustainability (7 indicators): Number of monitoring stations (station), PM2.5 Concentration (μg/m3), CO2 Emissions (metric tonnes of CO2 *per capita*), Solid Waste Collection (%), Wastewater Treatment (%), Solid Waste Recycling Share (%), Share of Renewable Energy (%).
- Governance and legislation (8 indicators): Voter Turnout (%), Access to Public Information (%), Civic Participation (%), Own Revenue Collection (%), Days to Start a Business (days), Subnational Debt (%), Local Expenditure Efficiency (%), Land Use Efficiency (Dimensionless).

3.2. A Full Permutation Polygon Synthetic Indicator (FPPSI) method for constructing a comprehensive index

On the basis of the selected indicator system, many ways may be employed to evaluate a city's prosperity. Typical approaches include the analytical hierarchy process (AHP), principal component analysis (PCA), entropy weight method, etc. In this paper, a Full Permutation Polygon Synthetic Indicator method (FPPSI) has been used to assess the level of prosperity of Da Nang City. The FPPSI method was developed by Feng Li and collaborators to assess urban sustainable development in China's Jining City (Feng Li et al., 2009). The

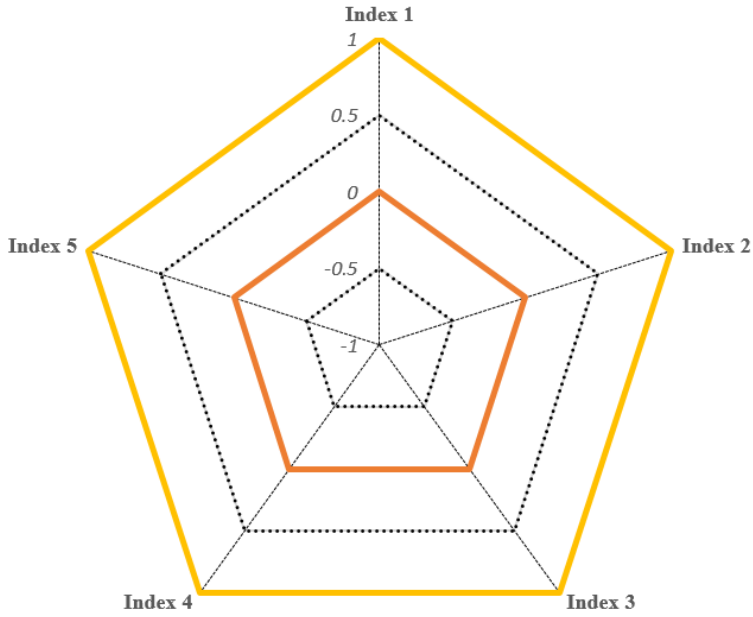

Fig. 2. Schematic of Full Permutation Polygon Synthetic Indicator Method
Source: Authors modified from (Xiao, 2017)

benefit of using FPPSI is that it incorporates the target's multifactor and systematic features. While the evaluation procedure lessens the impact of subjective elements, the aggregated evaluation findings make analysis and comparison easier (Feng Li et al., 2009). Additionally, FPPSI is not required when establishing the weight by expert subjective judgment, which lowers subjective randomness compared to the conventional simple weighing technique. FPPSI can modify the conventional additive technique for combining indicators by employing a multi-dimensional method that more accurately captures the integrative system concept that the whole is greater than the sum of its parts (Xu et al., 2016).

For indicator i, the normalized value S_i is expressed as:

$$S_i = \frac{(U_i - L_i)(X_i - T_i)}{(U_i + L_i - 2T_i)X_i + U_iT_i + L_iT_i - 2U_iL_i}$$

where S_i is the standardized value of indicator X_i; U_i is the upper limit of X_i, which is usually the highest value of X_i; L_i is the lower limit of Xi, which is commonly the lowest value of X_i; and T_i is the threshold value of X_i, which is usually the average value of X_i. The lower limit, the upper limit are determined by looking for the best and worst performances of cities in the world (UN Habitat, 2016). With negative variables (e.g., Under-five mortality rate), the highest numerical value is the worst and the lowest is the best. Meanwhile, for positive indicators, the highest numerical value is the best and the lowest is the worst (e.g., City product *per capita*). To eliminate the effects of extreme values, the values at 5% of the best and the worst, and 95% of the rest are taken as the upper limit, the lower limit, and the threshold value respectively. The standardization interval is [−1, +1]. Notably, S_i=−1 when X_i=L_i; S_i=0 when X_i=T_i; and S_i=1 when X_i=U_i. The inner portion of the critical zone shows that the normalized value of each indicator is less than

Table 1. Classification for city prosperity level

Level	Value of the synthetic indicator	Qualitative level
I	≥0.75	Excellent
II	0.5 – <0.75	Good
III	0.25 – <0.5	Moderate
IV	<0.25	Bad

Source: Authors quoted from (Feng Li et al. 2009)

Table 2. Data of indicator system used to evaluate city prosperity in Da Nang City in the period 2004–2019

Dimesion	Indicator	2004	2009	2014	2019	Upper limit[1]	Lower limit
1. Productivity Index	City Product *per capita* (USD, PPP)	3,914.7	6,972.6	8,732.7	13,047.8	108,819.0	714.6
	Old Age Dependency Ratio (%)	8.39	8.53	8.67	8.81	2.9	40.5
	Mean Household Income (USD, PPP)	11,071.95	19,061.18	24,935.49	28,235.7	44,773.0	6,315.0
	Economic Density (million USD/km^2)	2.33	4.85	7.03	11.6	857.4	0.0
	Economic Specialization (dimensionless)	0.0382	0.0506	0.063	0.0754	0.2	0.0
	Unemployment Rate (%)	5.16	6.49	3.76	3.55	1.0	28.2
	Employment to Population Ratio (%)	68.4	70.2	71.9	73.6	75.0	30.5
	Informal Employment (%)	58.5	52.9	50.5	46.5	11.0	75.0
2. Infrastructure Index	Improved Shelter (%)	96.2	97.4	99.3	99.5	98.0	84.8
	Access to Improved Water (%)	88.7	92.8	93.2	94.1	100.0	50.0
	Access to Improved Sanitation (%)	93.2	95.7	98.6	100.0	100.0	15.0
	Access to Electricity (%)	99.1	100.0	99.8	100.0	100.0	7.0
	Sufficient Living Area (%)	29.8	41.1	42.8	44.6	57.8	2.5
	Population Density (people/km^2)	2,464.0	3,149.0	3,565.0	4,031.0	15,000.0	0.0
	Physician Density (per 1000 population)	1.32	1.19	1.30	1.47	7.7	0.0
	Number of Public Libraries (per 100 000 population)	1.96	1.73	1.56	1.67	7.0	1.0
	Internet Access (%)	35.7	59.6	77.7	78.3	100.0	0.0
	Home Computer Access	15.1	33.1	52.2	57.3	100.0	0.0
	Average Broadband Speed (kbps)	30,560.0	35,980.0	38,900.0	40,940.0	87,088.0	470.0
	Use of Public Transport (%)	4.5	4.7	5.5	6.0	62.2	6.0
	Average Daily Travel Time (minutes)	34.2	34.7	35.7	36.3	30.0	60.0
	Length of Mass Transport Network (km/million population)	54.2	65.4	75.6	80.3	80.0	0.0
	Traffic Fatalities (fatalities per 100,000 people per year)	19.5	14.8	9.3	0.5	1.0	31.0
	Affordability of Transport (%)	19.4	17.3	17.0	14.3	4.0	26.0
	Street Intersection Density (intersections per km^2)	30.3	31.5	32.7	34.4	100.0	0.0
	Street Density (km/km^2)	7.5	8.7	9.3	10.6	20.0	0.0
	Land Allocated to Streets (km^2)	7.5	9.9	15.4	28.3	36.0	6.0
3. Quality of Life Index	Life Expectancy at Birth (year)	75.4	75.7	75.9	76.1	83.5	49.0
	Under-Five Mortality Rate (‰)	14.3	13.7	13.3	12.6	2.2	181.6

[1]The lower limit and the upper limit are recommended by UN Habitat in the City Prosperity Index: Methodology and Metadata report.

[2] The data for indicators to evaluate city prosperity in Da Nang City were collected, synthesized and calculated by authors from GIS map and remote-sensing data, and official documents of Vietnamese government, Local government of Da Nang City such as: The Vietnam Population and Housing Census, The Vietnam Household Living Standards Survey, The Vietnam Informal Employment Report, Da Nang Statistical Yearbook.

table continiued from previous page

Dimesion	Indicator	2004	2009	2014	2019	Upper limit[1]	Lower limit
	Vaccination Coverage (%)	98.7	99.5	98.5	97.04	100.0	0.0
	Maternal Mortality (mothers per 100,000 live births)	0.00	0.00	0.00	0.02	1.0	1100.0
	Literacy Rate (%)	94.8	96.5	97.8	98.7	99.9	15.0
	Mean Years of Schooling (years)	8	8.3	8.6	9.1	14.0	0.0
	Early Childhood Education (%)	100.0	98.5	99.4	96.5	100.0	0.0
	Net enrollment rate in higher education (%)	12.7	17.8	22.5	27.9	100.0	0.0
	Homicide rate (homicides per 100,000 inhabitants)	0.91	0.85	0.76	0.71	1.0	1654.0
	Theft rate (thefts per 100,000 inhabitants)	46.4	38.8	33.3	26.6	25.5	6159.1
	Accessibility to Open Public Areas (%)	4.3	8.2	33.2	58.7	100.0	0.0
	Green Area *per Capita* (m^2/person)	1.1	1.62	4.5	7.51	15.0	0.0
4. Equity and Social Inclusion Index	Gini Coefficient (constant)	0.314	0.356	0.344	0.334	0.2	0.6
	Poverty Rate (%)	4.05	5.13	1.00	0.69	0.0	81.3
	Slums Households (%)	3.9	2.6	0.2	0.5	0.0	80.0
	Youth Unemployment (%)	25.1	20.1	11.4	10.1	2.7	62.8
	Equitable Secondary School Enrollment (dimensionless)	0.97	0.98	0.99	1.00	1.0	0.0
	Women in Local Government (%)	21.5	23.6	28	24	50.0	0.0
	Women in Local Work Force (%)	49.2	48.3	49.4	48.1	50.0	0.0
	Land Use Mix (Dimensionless)	0.34	0.42	0.49	0.48	1.6	0.0
5. Environmental Sustainability Index	Number of monitoring stations (station)	0.0	0.0	1.0	1.0	2.0	0.0
	PM2.5 Concentration ($\mu g/m^3$)	14.6	15.3	17.1	18.8	10.0	20.0
	CO_2 Emissions (metric tonnes of CO_2 *per capita*)	6.7	7.4	7.8	8.1	0.0	40.3
	Solid Waste Collection (%)	82.0	85.0	93.0	95.0	100.0	0.0
	Wastewater Treatment (%)	52.6	50.9	56.3	60.0	100.0	0.0
	Solid Waste Recycling Share (%)	5.5	7.0	8.5	12.0	50.0	0.0
	Share of Renewable Energy (%)	4.1	5.3	7.7	9.7	20.0	0.0
6. Governance and Legislation Index	Voter Turnout (%)	95.0	99.5	99.6	99.9	100.0	0.0
	Access to Public Information (%)	54.0	65.0	73.0	82.0	100.0	0.0
	Civic Participation (%)	5.50	5.28	4.83	4.50	100.0	0.0
	Own Revenue Collection (%)	96.8	94.3	90.3	95.0	80.0	17.0
	Days to Start a Business (days)	12.0	12.0	9.0	6.0	2.0	208.0
	Local Expenditure Efficiency (%)	103.5	163.7	116.4	175.0	100.0	200.0
	Land Use Efficiency (dimensionless)	0.63	0.70	0.83	0.86	0.0	3.0

the critical value and so has a negative value. The exterior area shows that the normalized value of each indicator is more than the critical threshold and positive, as illustrated in Fig. 2.

The composite index of FPPSI is defined as the ratio of the mean of all the irregular polygon area to the central polygon area. The value of composite index of permutations polygons of each dimension can be obtained as follows:

$$S = \frac{\sum_{i\#j}^{i,j}(S_i + 1)(S_j + 1)}{2n(n-1)}$$

where S is the value of the synthetic indicator. The value of the synthetic indicator was classified into a four-level classification system based on the value of S as shown in Table 1.

4. Results

Based on the data for Da Nang City in the period 2004–2019 described in Table 2, the authors evaluated the prosperity of Da Nang City from six perspectives: productivity; infrastructure development; quality of life; equity and social inclusion; environmental sustainability; and governance and legislation. The authors then synthesized the results to provide a single comprehensive indicator of prosperity.

4.1. Productivity

The productivity dimension measures how cities generate wealth and contribute to economic growth and development and how they generate individual income, employment, and equal opportunities that advance adequate living standards for the entire population (UN Habitat, 2013).

Based on 2004, 2009, and 2014 data, the synthetic indicator for productivity in Da Nang City was low (0.14, 0.18, 0.23 respectively), and ranks as level IV (bad). In 2019, the index for productivity increased gradually to 0.26 (level III, moderate) (Fig. 3). The major reasons for this problem are low *per capita* GDP, household income, economic density, and economic specialization. In particular, the economic density was very low due to more than 50% of the Da Nang City area being rural with agriculture as the main economic activity. However, Da Nang City's economic structure has shifted to service and industrial activities, leading to increasing both GDP *per capita*l and household income recently, as shown in Table 2. On the aspect of employment, both the employment-to-population ratio and the unemployment rate have a very good status. This reflects the city's ability to create new jobs and solve employment for its labor force. Da Nang City

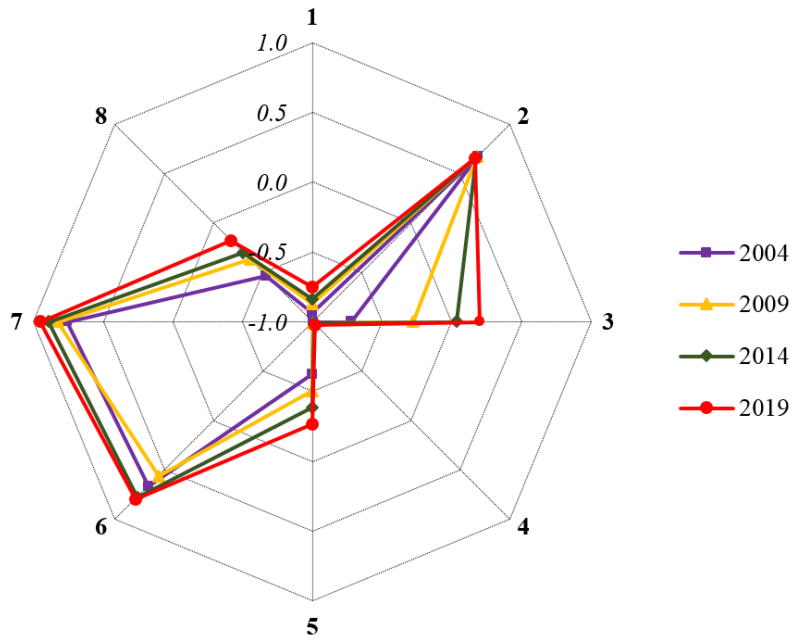

Fig. 3. Comprehensive evaluation of Productivity dimension in Da Nang City, (1) City Product per capita, (2) Old Age Dependency Ratio, (3) Mean Household Income, (4) Economic Density, (5) Economic Specialization, (6) Unemployment Rate, (7) Employment to Population Ratio, (8) Informal Employment
Source: own elaboration

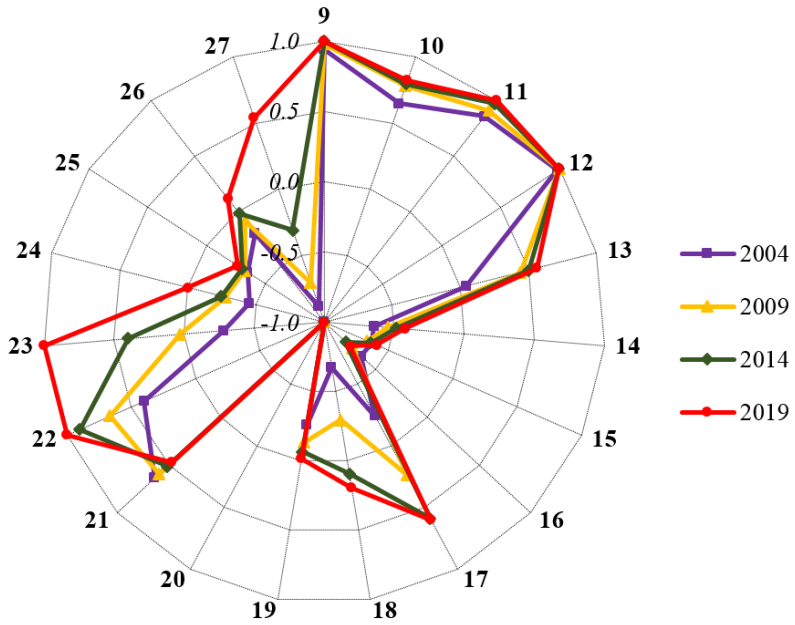

Fig. 4. Comprehensive evaluation of Infrastructure Development dimension in Da Nang City
(9) Improved Shelter, (10) Access to Improved Water, (11) Access to Improved Sanitation, (12) Access to Electricity, (13) Sufficient Living Area, (14) Population Density, (15) Physician Density, (16) Number of Public Libraries, (17) Internet Access, (18) Home Computer Access, (19) Average Broadband Speed, (20) Use of Public Transport, (21) Average Daily Travel Time, (22) Length of Mass Transport Network, (23) Traffic Fatalities, (24) Affordability of Transport, (25) Street Intersection Density, (26) Street Density, (27) Land Allocated to Streets.
Source: own elaboration

should keep going to reduce the unemployment rate further and address the employment-to-population ratio to ensure the best employment environment in the city.

4.2. Infrastructure Development

The infrastructure dimension assesses a city's level of accomplishment in infrastructural development. It shows how a city uses its resources to deploy an excellent functional and efficient infrastructure. Physical assets and amenities such as mains water, sewerage, power supply, road network, and information and communications technology (ICT) are required to sustain the population, improve the economy, and ensure a high quality of life.

In 2004, the index for infrastructure in Da Nang City was 0.20 (bad, level IV). However, this index increased significantly to moderate (level III) with a score of 0.27 in 2009, 0.33 in 2014, and 0.41 in 2019 (Fig. 4). A moderate grade indicates an infrastructure system that is somewhat inefficient. The strength of the city's infrastructural development is its housing sector, with a high level of improved shelter, access to improved water, access to improved sanitation, and access to electricity. Moreover, the urban mobility of Da Nang City has a high level related to average daily travel time, length of mass transport network, and traffic fatalities. The weaknesses in the infrastructure index are associated with some very low factors of social infrastructure (such as population density, physician density, number of public libraries), and urban transportation (such as the use of public transport, affordability of transport, intersection density, street density). Nonetheless, land allocated to streets was dramatically increase due to the fact that Da Nang City has developed more and more new urban areas with extremely high street density in recent years.

4.3. Quality of Life

Quality of life refers to happiness, good health, and the general well-being of individuals and society. The quality of life dimension measures the city's achievements in providing essential amenities that promote happiness and general well-being. They include basic services and amenities such as education, healthcare, recreation, safety, security, etc. They are required for the inhabitants to live long,

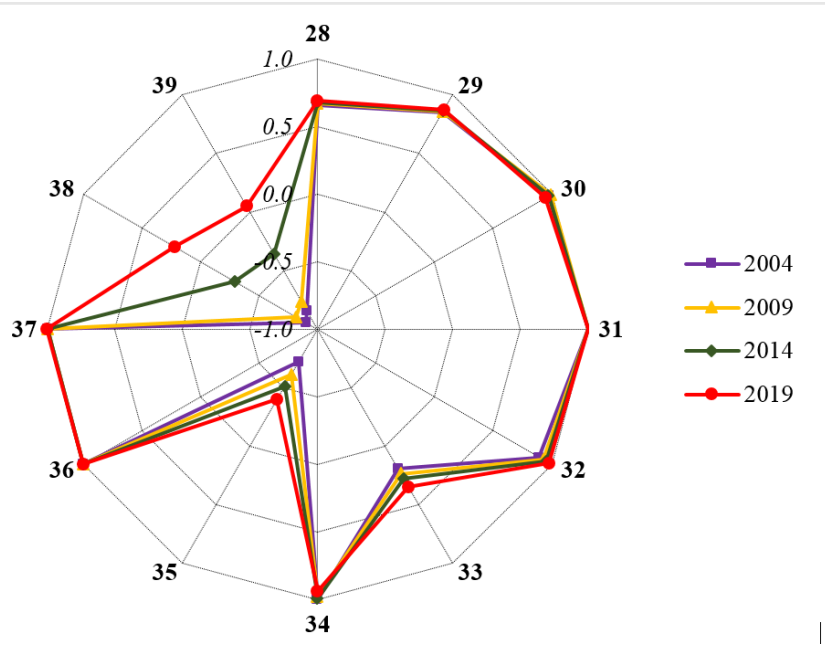

Fig. 5. Comprehensive evaluation of Quality of Life dimension in Da Nang City
(28) Life Expectancy at Birth, (29) Under-Five Mortality Rate, (30) Vaccination Coverage, (31) Maternal Mortality, (32) Literacy Rate, (33) Mean years of Schooling, (34) Early Childhood Education, (35) Net enrollment rate in higher education, (36) Homicide rate, (37) Theft rate, (38) Accessibility to Open Public Areas, (39) Green Area *per Capita*
Source: own elaboration

satisfying lives and to maximize their individual potentials (UN Habitat, 2013).

The indicator for the quality of life in Da Nang City was good (level II) and improved from 0.5 in 2004, to 0.52 in 2009, 0.59 in 2014, and 0.67 in 2019 (Fig. 5). The good quality of life in the city can be linked to the good healthcare system (low under-5 mortality rate, very high vaccination coverage, and low maternal mortality), safety and security (very low homicide rate and theft rate). Nevertheless, the education sector of Da Nang City still suffers from a low enrollment rate in higher education. Besides that, the mean years of schooling also needs to be addressed. Moreover, the availability of adequate public spaces for recreation and socialization is a weak sub-dimension, as are the low level of green area *per capita* and poor accessibility to open public spaces.

4.4. Equity and Social Inclusion

The equity and social inclusion factors assess how cities distribute affluence among their residents. Cities that are inclusive ensure that no parts of the population are left behind in poverty or deprivation as they grow. More socially inclusive and economically equitable cities are more productive and have a higher standard of living and quality of life (UN Habitat, 2013).

Based on the 2004–2019 data, the synthetic indicator for equity and social inclusion dimension in Da Nang City was good (level II) with 0.54 in 2004, 0.55 in 2009, 0.63 in 2014, and 0.62. in 2019 (Fig. 6). The Gini coefficient, poverty rate, slums households, youth unemployment, equitable secondary school enrollment, and women in the local workforce are all favorable factors that reflect the high level of economic equality, social inclusion, and gender inclusion in Da Nang City. However, the number of women in the local government is still low, calling for the prioritization of policies that promote women's participation in local government. The city still has to strengthen its ability to provide jobs for young people in order to reduce youth unemployment. Furthermore, a thriving city strives to balance its systems and functions by distributing main urban activities (UN Habitat, 2016). However, most of Da Nang City's economic activities and population are concentrated in the inner city (only about 20% of the territory). Hence, the very low level of land use mix (a mix of residences, workplaces, and local commerce) reflects the unbalanced situation of the city's spatial distribution of activities, structure, and organization.

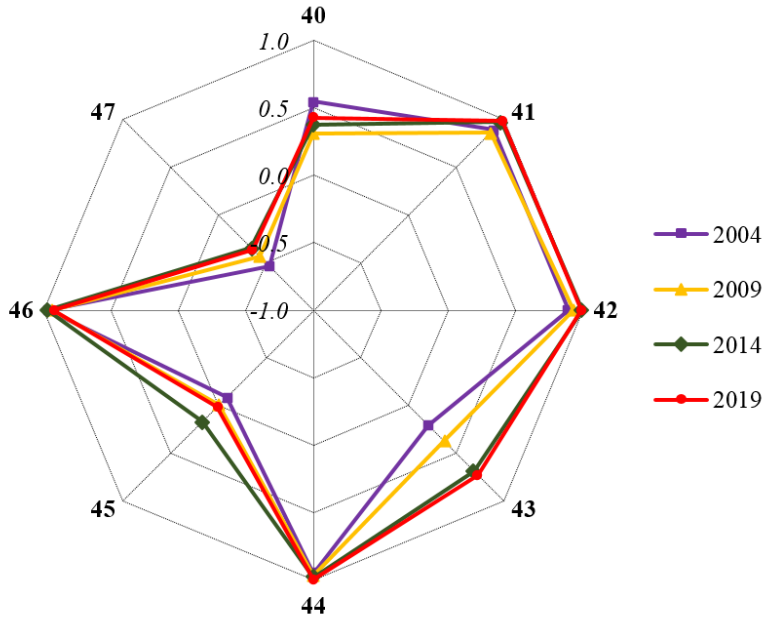

Fig. 6. Comprehensive evaluation of Equity and Social Inclusion dimension in Da Nang City
(40) Gini Coefficient, (41) Poverty Rate, (42) Slums Households, (43) Youth Unemployment, (44) Equitable Secondary School Enrollment, (45) Women in Local Government, (46) Women in Local Work Force, (47) Land Use Mix
Source: own elaboration

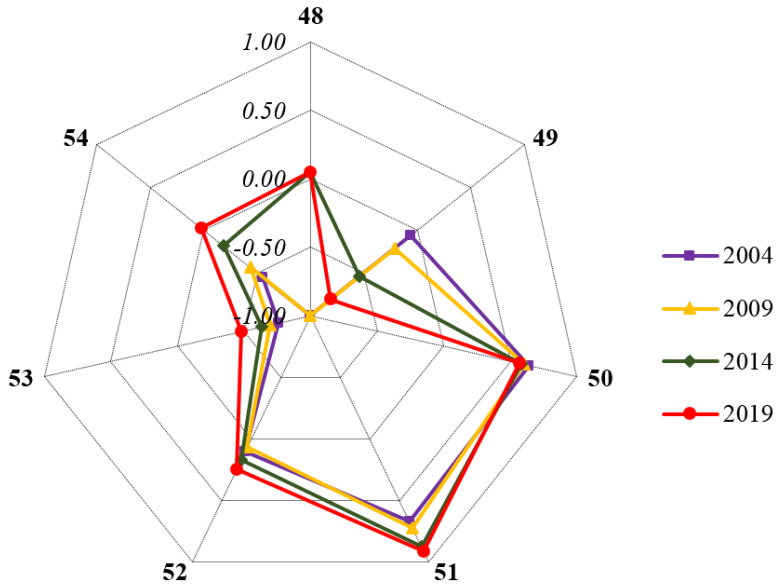

Fig. 7. Comprehensive evaluation of Environmental Sustainability dimension in Da Nang City
(48) Number of monitoring stations, (49) PM2.5 Concentration, (50) CO2 Emissions, (51) Solid-Waste Collection, (52) Wastewater Treatment, (53) Solid-Waste Recycling Share, (54) Share of Renewable Energy
Source: own elaboration

4.5. Environmental Sustainability

As they expand and develop economically and socially, prosperous cities ensure that the city's environment does not deteriorate and remains healthy and habitable, and that the city's natural resources are conserved for future generations.

The indicator for environmental sustainability in 2004 and 2009 were bad (0.17 and 0.18, level IV). This index increased gradually, to 0.26 in 2014 and 0.28 in 2019 at level III (moderate) (Fig. 7). The extremely

low scores are associated with the city's high level of PM2.5 concentration and low level of solid-waste recycling share. Although the PM2.5 concentration in Da Nang City was within acceptable limits of Vietnamese standards (Vietnam Environment Administration, 2013), it was still significantly high compared to the UN's suggested measuring threshold. Although the city has an efficient solid-waste collection system (95%), only 12% of its solid waste is recycled. Hence, the proportion of recycled solid waste was very low despite the high rate of solid-waste collection. As a result, the city is at risk of landfills becoming a source of pollution. Da Nang City should invest in solid-waste recycling to minimize environmental pollution caused by solid-waste dumps. Furthermore, to enhance the score for the percentage of renewable energy indicators and make the city's environment more sustainable for the future, there is a need to begin adopting alternative forms of renewable energy.

4.6. Governance and Legislation

A decent society is not just financially prosperous but also socially inclusive, environmentally sustainable, and well-governed. Good governance and the rule of law foster a sense of security and well-being. On the other hand, corruption, lawlessness, dishonest politicians, uneven government services, massive discrimination, insider transactions, and other issues produce a lot of displeasure (Sachs, 2015). To provide a suitable environment for the city to appropriately manage other drivers of prosperity and attain sustainability, competent governance and appropriate laws are essential (UN Habitat, 2019).

Based on the available information, Da Nang City's overall governance and legislation index was in general good (level II) with 0.53 in 2004, 0.45 in 2009, 0.57 in 2014, and 0.50 in 2019 (Fig. 8). Da Nang City gets a high level for voter turnout, access to public information, own revenue collection, subnational debt, days to start a business, and land-use efficiency. In reality, Da Nang City has consistently rated high in the list of provincial competitiveness in Vietnam due to significant advances in economic management mechanisms and policies (Malesky et al., 2020). However, citizen participation was very low, and local expenditure efficiency was unstable.

4.7. Comprehensive evaluation of city prosperity in Da Nang City

As of 2004–2019, the comprehensive indicator for urban prosperity in Da Nang City was at level III

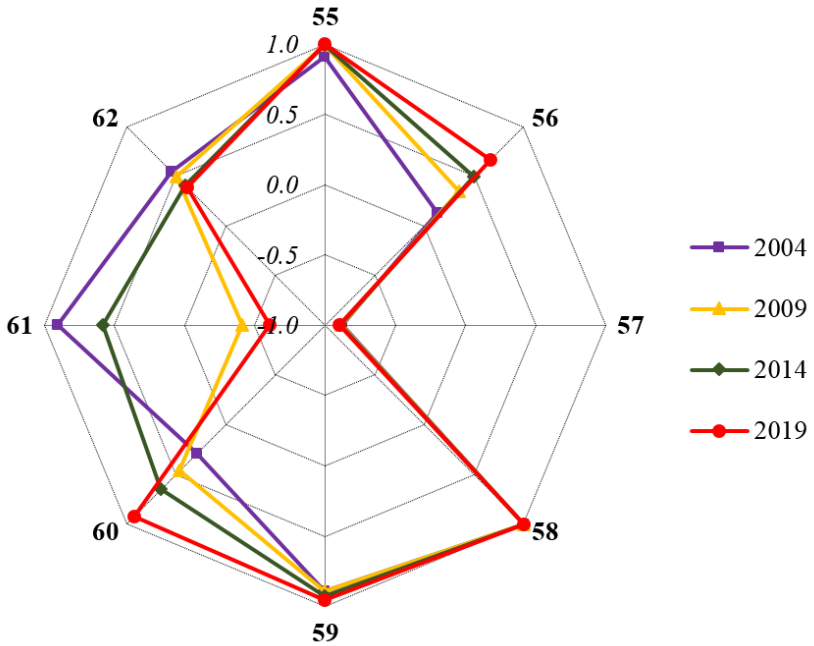

Fig. 8. Comprehensive evaluation of Governance and Legislation dimension in Da Nang City
(55) Voter Turnout, (56) Access to Public Information, (57) Civic Participation, (58) Own Revenue Collection, (59) Days to Start a Business, (60) Subnational Debt, (61) Local Expenditure Efficiency, (62) Land Use Efficiency
Source: own elaboration

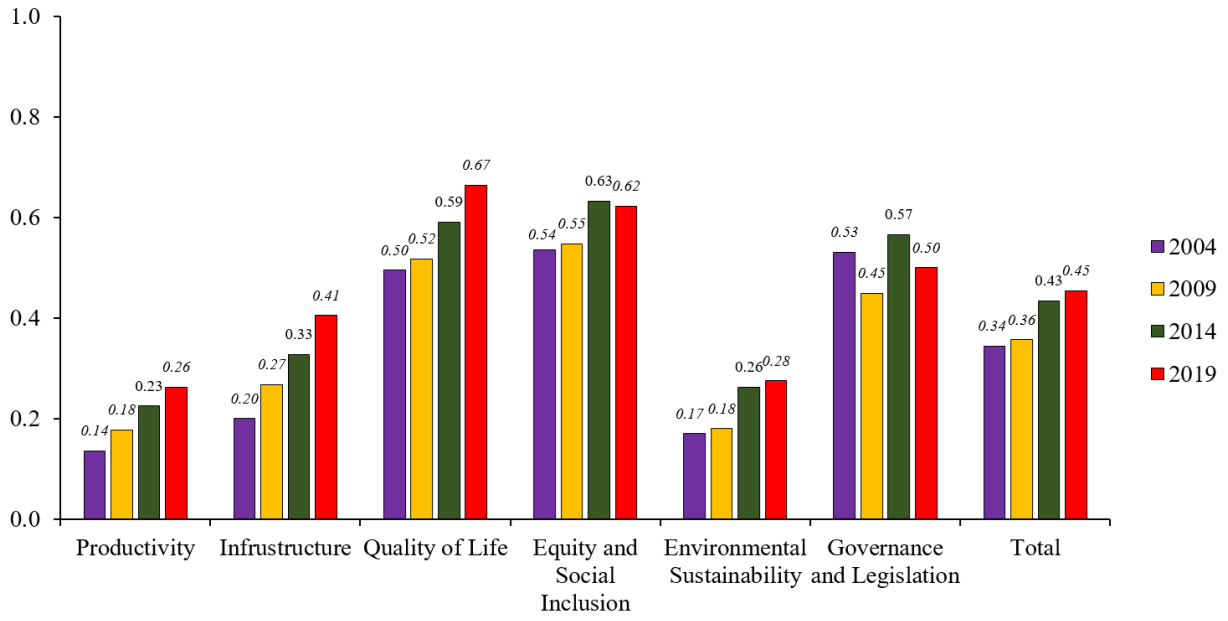

Fig. 9. Comprehensive evaluation of city prosperity in Da Nang City
Source: own elaboration

and progressively increased from 0.34 in 2004, 0.36 in 2009, 0.43 in 2014, to 0.45 in 2019, which represents a moderate status.

The diagram illustrates the lack of balance between dimensions of prosperity in Da Nang City. Three of the six dimensions are evaluated as good status, while the remaining three are considered moderate. The good dimensions include quality of life, equity and social inclusion, and governance and legislation. Meanwhile, other indices such as infrastructure, productivity, and environmental sustainability were moderate (see Fig. 9). A balanced city ensures that the citizens do not suffer extreme deprivations associated with a very low index. Hence, Da Nang City should make progress and equilibrium between and within dimensions of the prosperity index to be sustainable and prosperous.

5. Discussion and conclusion

Urban sustainable development and prosperity is a long-term objective that involves developing a more vital synthesis of social, economic, environmental, and governance factors. The CPI indicator system developed by UN Habitat is a novel tool to evaluate urban prosperity that is comprehensive, integrated, and crucial for promoting and monitoring socio-economic development, inclusion, and progressive fulfillment of urban-related human rights for everyone. The authors have used this indicator system and applied the FPPSI method to assess city prosperity in the case study of Da Nang City of Viet Nam in the period 2004–2019. Instead of using subjective expert judgments on the values of coefficients, the FPPSI technique just asks analysts to specify upper and lower bounds and crucial values, which should lessen the amount of bias that may skew subjective evaluations. This approach is more accurate, measurable, and effective. The ability to measure the indicators and quantify progress towards a target is another benefit of the FPPSI approach. The FPPSI technique at least enables planners to select measurable indicators that are related to management goals, despite the fact that indicator selection is rather arbitrary. The FPPSI technique deviates from the usual approach to combining indicators by employing a multi-dimensional approach that more accurately reflects the integrative system concept that the whole is greater than the sum of its parts (Feng Li et al, 2009).

The overall city prosperity index implies that the city has a moderate level of prosperity with some strong dimensions such as quality of life, equity and social inclusion, and governance and legislation index. However, the CPI index also shows that Da Nang City has some moderately weak factors of prosperity related mainly to the environment, productivity, and infrastructure. Therefore, to facilitate the sustainable development of Da Nang City, a set of strategic projects focusing on the advanced infrastructure services, intensive productivity investments and effective environmental

solutions should be implemented for the near future. Moreover, the index is a tool that allows municipal officials and local and national stakeholders to identify possibilities and possible areas of action for their communities to become more wealthy. Hence, the results of our analysis should thus support policies taken to encourage sustainable development of the city and enable monitoring of the effects of local government decisions. However, the study used only the upper and lower thresholds suggested by UN Habitat to compare Da Nang City's prosperity to global standards, future research should compare and evaluate the level of prosperity among large cities in Vietnam using the FPPSI method.

Acknowledgements

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