Floor Area Ratio (Far) And Sustainable Urban Living Observing Data Using Urban Modeling Interface (UMI) Case Yogyakarta Indonesia

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Abstract.

Floor area ratio (FAR) is a measurement, expressed as a decimal, that describes the total amount of usable floor space in a building compared to the size of the lot that the building is on. FAR using by building planner to maintain development standards and guide or restrict the development of local communities. In many cases FAR is an element of sustainability in urban environments so that residents are able to survive in a limited land environment. The FAR value is set locally by the local government. This research was conducted in one of block area of the urban in the center city of Yogyakarta, namely Malioboro. The measurement results with the urban modeling interface (UMI) software show that urban living in this area has a FAR value below the existing reference standard of 4.00. Averarge FAR is 1.125. This means that the formations of urban living still very suitable for habitation. It could be that the FAR value of 4 is a long-term orientation to maintain the quality quality of urban living dan sustainability.

Keywords: *Floor Area Ratio, Urban Living, Buildings and Building Ratio.*

I. INTRODUCTION

Observing urban living in various cities in the world, almost all cities have problems with sustainability. City developments that lead to urbanization and an increase in the number of residential houses and commercial buildings can reduce the quality of life of the people living in the vicinity as well as threaten its sustainability. In the 2030 Agenda related to the sustainable development agenda (SDGs), which is a global agenda in order to realize sustainable development economically, socially, environmental quality, and good governance, it is stated that in one of the fundamental supports for environmental development, namely article no. 11 which mentions sustainable cities and settlements [1]. The clause states that the main goal is to make urban areas and settlements inclusive, safe, responsible and sustainable.Sustainable cities are a global issue of urban development worldwide for more than 40 years [2]. The existence of ecocity, liveable city, smart city, symbiocity, green city is part of the green agenda to encourage sustainable urban development. Cities such as Stockholm, Curitiba, Yokohama, Finland and Singapore are some examples of cities that often become meccas for sustainable urban development. Quoted statement from Grober [3] which was adapted from the Brundtland Commission in 1987 that the term sustainable development is current development without neglecting future generations both socially, economically and environmentally.Based on a number of studies on urban living both in Indonesia and in various big cities in the world, one of the strategies for implementing sustainable development is land efficiency. Land efficiency is carried out by implementing a balance between land use and building density.

This is known as the floor area ratio (FAR). FAR is the ratio of the total floor area of the building (gross floor area) to the area. This FAR provision is often used as one of the regulations in urban planning along with the ratio of buildings to land. The term may also refer to limits imposed on those ratios through zoning. FAR and land use are two examples of fundamental parameters in urban master plans.How does this FAR benefit the sustainability of urban community life? A study revealed that FAR affects the spatial and temporal distribution of cooling systems in an area [4]. FAR also affect to energy used in buildings [5]. FAR can also be used to control building density optimally, ratio with utilities and infrastructure to reduce traffic, water and land [6]. FAR is also considered to be very effective in controlling the development of physical development, particularly buildings that are slower, which is referred to as the Low Impact Development strategy (LID) [7]. Each city has different FAR provisions. FAR itself is an official stipulation from the local government which is calculated taking into account the speed of growth of the area and limited land. The following is an example of FAR values in several cities in the world, including Indonesia:

Table. 1. FAR Constraint In Many Big Cities

FAR Constraint Value	City
≤ 16,0 :	Kota Chicago, USA [8] [9]
≤ 3,0:	Vancouver, Canada, North America [8]
≤ 4,0:	Cina [10]
≤ 15,0:	New York, USA [7]
≤ 12,6:	Singapore [7]
≤ 8,1:	Sydney, Australia [7]
≤ 5,0:	Jakarta, Indonesia [11]
≤ 4,0:	Yogyakarta, Indonesia [12]

Although FAR has often been used as a provision in building utilization and land use in an area, in practice this FAR often cannot be fulfilled optimally. Comparison of the floor area and the area of the boundary area provides an overview of the size of the building capacity and user comfort from a predetermined value. This research is an experimental research that aims to measure the value of FAR in a densely populated and building area, which has the characteristics of mixed used land in Malioboro, Yogyakarta.

Fig 1. Visual of Malioboro Area and Observed Location

II. METHODS

FAR or floor area ratio is a fundamental parameter that influences sustainability and influences the planning of a residential area. To obtain the FAR value of the area under study, researchers need data in digital form such as a building model that will include the area and total floor area of the building and the boundaries of the land area of the area under study. The value obtained can indicate the level of building density in the research area and determine the sustainability of the land use.

The sustainability of the existing density of buildings in a settlement area under study will affect the results of each building in terms of energy consumption, sunlight reception, the size of the need for building materials, and the level of community mobility within the area.To measure the FAR value in a predetermined area, namely one of the residential blocks in the Malioboro area of Yogyakarta city, this research will be used Urban Modeling Interface (UMI) software [13]. Through UMI, a site simulation or better known as FAR will be carried out by calculating the ratio of the total floor area of each building to the area of the boundary. FAR calculations are run from within the UMI Bundle simulation panel tab by executing the Rhino command 'UmiCalculateFAR'

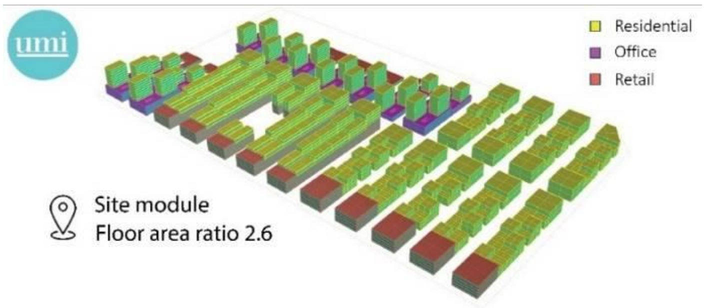


Fig 2. Visualization of Site Modul of FAR [14]

$$\text{Floor area ratio} = \frac{\text{Gross building floor area}}{\text{Total property area}}$$

Fig 3. Formula to Calculate FAR

To be able to run UMI to get a numerical and visual picture, data is needed, namely: 1) Building function, 2) Number of building floors, 3) Building dimensions (length, width, height), 4) Total floor area of the building, 5) Total area area, and 6) Number of occupants of the building. Some of the advantages obtained from using UMI Software: a) UMI is software that is integrated with Rhinoceros, so that a model of a built environment in a small to large scope can be modeled accurately and precisely; b) UMI can automatically calculate occupant density and building floor area, c) UMI allows evaluating several simulations related to environmental performance in an integrated manner, d) UMI has categorization layers that are diverse enough to define elements in a built environment across scales [15].

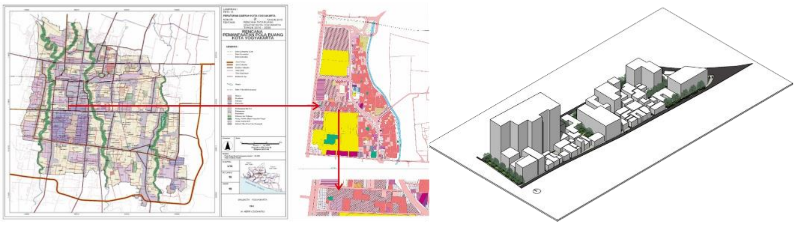
III. RESULT AND DISCUSSION

Result

The intensive observation area is divided into 4 zones referred to as Zone 1 (Sosrokusuman), Zone 2 (Suryatmajan), Zone 3 (Pajeksan), and Zone 4 (Jogonegaran). The condition of each zone is actually almost the same as a densely populated area, in the form of an urban village, and occupying mixed-use land with quite a variety of building heights. The majority are commercial buildings such as shops, malls and hotels. Retail and hotel functions are the dominant buildings (49%). The following are the results of observations and the results of FAR measurements in the four observed zones

Zone 1. Sosrokusuman

Sosrokusuman village which became the first observed village. This village has a land area of 6,929 m2 (0.69 Ha). The maximum building height in the simulation in this village area is up to 32 meters or 8 floors for hotel buildings. While the houses, shop houses and lodging houses/boarding houses reach 16 meters or have 4 floors. The FAR simulation results for Sosrokusuman village are 1.71. The result is the ratio between the land area (6,929 m2) and the total floor area of all building functions (11,872 m2).



Building Function

Function	House	House/Retail	House/Homestay	Hotel	Retail	Public Facilities	Number of Buildings
Number (Unit)	18	6	18	9	5	-	56
Percentage (%)	32.14	10.71	32.14	16.07	8.93	0	100.00

Building Hight

Number of Floor Level	1	2	3	4	8	Number of Buildings
Number (Unit)	37	2	7	7	3	56
Percentage (%)	66.07	3.57	12.50	12.50	5.36	100.00

Fig 4. Site Information at Zone 1 Sosrokusuman

Zona 2. Suryatmajan

The second village, Suryatmajan, has an area of 38,910 m2 (3.89 Ha) with a total floor area of 31,752 m2. In this village area there are government offices area which is directly adjacent to the village area. The maximum building height in the simulation in the village area is 32 meters or 8 floors for hotel buildings and office buildings with a maximum of 3 floors or 12 meters. While the house buildings, shop houses and lodging houses reach 12 meters or have 3 floors. The FAR simulation results for Kampung Suryatmajan are 0.82. The result is the ratio between the land area (38,910 m2) and the total floor area of all building functions (31,752 m2).

Building Function

Function	House	House/Retail	House/Homestay	Hotel	Retail	Public Facilities	Number of Buildings
Number (Unit)	90	26	13	7	13	39	56
Percentage (%)	47.87	13.83	6.91	3.72	6.91	20.74	100.00

Building Hight

Number of Floor Level	1	2	3	4	8	Number of Buildings
Number (Unit)	127	42	16	2	1	188
Percentage (%)	67.55	1.06	8.51	1.06	0.53	100.00

Fig 4. Site Information at Zone 2 Suryatmajan

Zone 3. Pajeksan

Kampung Pajeksan is the next observation zone. This area has a maximum building height in the simulation in the village area which is up to 28 meters or 7 floors for hotel buildings. The house building, the shop house building and the lodging/boarding houses building are 16 meters or 4 floors. The FAR simulation result for Pajeksan village is 1.09. This value is obtained from a comparison of the land area of 25,157 m2 with a total floor area of 27,499 m2.

Building Function

Function	House	House/Retail	House/Homestay	Hotel	Retail	Public Facilities	Number of Buildings
Number (Unit)	170	30	16	4	34	17	271
Percentage (%)	62.73	11.07	5.90	1.48	12.55	6.27	100.00

Building Hight

Number of Floor Level	1	2	3	4	8	Number of Buildings
Number (Unit)	145	106	13	6	1	271
Percentage (%)	53.51	39.11	4.80	2.21	0.37	100.00

Fig 5. Site Information at Zone 3 Pajeksan

Zone 4. Jogonegaran

Kampung Jogonegaran which is located has a maximum building height in the simulation reaching 20 meters or 5 floors for hotel buildings. While the house buildings, shop house buildings, and lodging houses/boarding houses reach 16 meters or have 4 floors. The FAR simulation results for Pajeksan village are 0.88. This value is obtained from a comparison of the land area of 26,527 m2 with a total floor area of 23,432 m2.

Building Function

Function	House	House/Retail	House/Homestay	Hotel	Retail	Public Facilities	Number of Buildings
Number (Unit)	202	44	13	9	4	1	56
Percentage (%)	73.99	16.12	4.76	3.30	1.47	0.37	100.00

Building Hight

Number of Floor Level	1	2	3	4	8	Number of Buildings
Number (Unit)	200	59	9	4	1	273
Percentage (%)	73.26	21.61	3.30	1.47	0.37	100.00

Fig 6. Site Information at Zone 3 Jogonegaran

Discussion

The measurements in the four zones show that the FAR value in each zone block is below 4.0 which is the standard FAR value set by the local government. The interpretation of the results of this measurement is that the FAR value in the observed area gives good results. Urban settlements in this area can be said to have a relatively high level of sustainability. The average FAR value, which is only around 1,125, means that this area is expected to continue to be sustainable for the next few decades, when compared with the average speed of infrastructure development, especially buildings in this area.

Table 2. The Result of FAR Measurement Each Zone

Zone	Land Area (m2)	Total Area (m2)	FAR Limit	FAR Value
Zone 1 Sosrokusuman	6.929	11.872	≤ 4,0	1.71
Zone 2 Suryatmajan	38.910	31.752		0.82
Zone 3 Pajeksan	25.157	27.499		1.09
Zone 4 Jogonegaran	26.527	23.432		0.88
			Average	1.125

Based on table 2 above, the highest building density is in Zone 1 Sosrokusuman while the lowest building density is in the Suryatmajan village. This is influenced by the condition of the land area in Sosrokusuman which has a ratio of available land area that is lower than the total floor area. The following is a visualization of FAR using UMI 3.0.

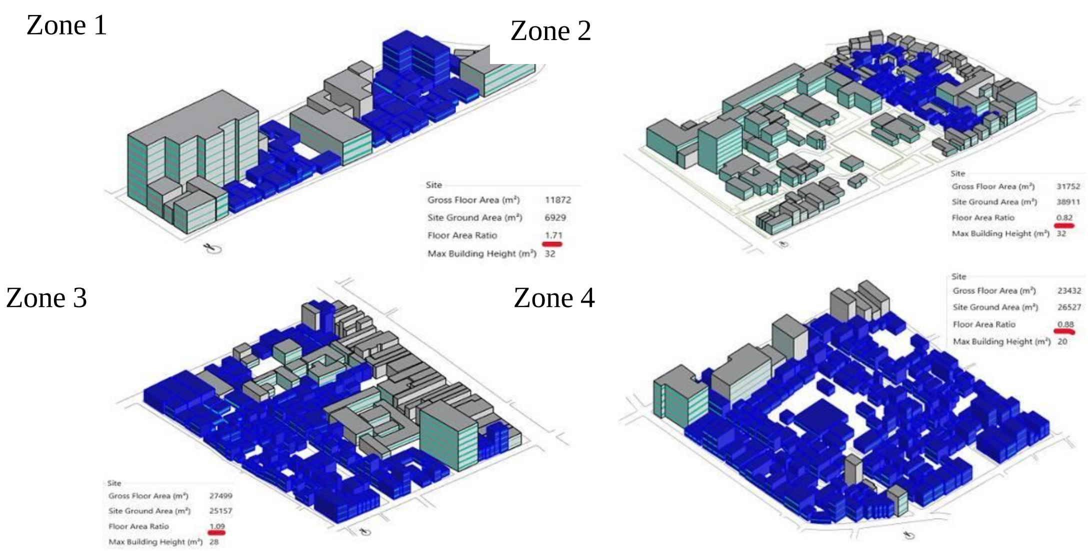


Fig 7. Visualization and Simulation Throughout the Observed Area

What is the relationship between the determination of the FAR value < 4.00 and the sustainability of the Malioboro area? It seems that through the determination of the FAR 4.00, the government has a vision of developing this area as a commercial area which will continue to develop in the future, even with very limited land. Based on that argument, giving flexibility to anyone, both individuals and building planners who want to develop their current building, or maybe change the function of a building, for example from a residential building to a commercial building such as a hotel or mall, has many floors, so this FAR value is the best solution.

This policy will of course invite criticism because of the characteristics of the Yogyakarta Region which historically is a city consisting of a number of urban villages [2, 16]. So that in the future it is very likely that the FAR 4.00 provisions need to be reviewed.It has been mentioned before that FAR can be used as a policy reference to slow down the impact of development (Low Development Impact)[7] on buildings in an urban area that is densely populated and has limited land. However, setting the numbers wisely by taking into account regional characteristics, the history of the city's formation, and other socio-cultural characteristics, especially for the case of Yogyakarta, will be produced a more accurate and optimum FAR figure. Properly FAR value will certainly guarantees the sustainability of the environment and its residents.

IV. CONCLUSION

The results of calculations in the observation area, namely in the Malioboro area, show an average FAR of 1,125. This value is far below the standard value set by the government of 4.0. The overall results of FAR measurements in each zone are Zone 1 (1.71), Zone 2 (0.82), Zone 3 (1.09) and Zone 4 (0.88). The results of this FAR when compared with the land area and total area show that Zone 1 is the zone with the highest population density, the 2nd most densely populated zone is zone 4, then zone 3, and the zone with the lowest population is zone 2.

FAR in the Malioboro area is still appropriate of the sustainability of urban life in this area. Setting the FAR velue at 4.00 is very likely to be expected as a strategy to anticipate the speed of development of buildings on very narrow land. Thus the development of buildings vertically is the choice of building construction models that can be carried out in this area. However, by considering the existing conditions where the current FAR value is still very far below the standard value, then the determination of FAR 4.00 needs to be reviewed periodically, so that the determination of the reference FAR number can be more accurate and have an optimal impact on the sustainability of urban living.

V. ACKNOWLEDGMENTS

The authors are grateful to the LPDP (https://lpdp.kemenkeu.go.id) who has been financed my study at doctoral program, Departemen Architecture and Planning, Gadjah Mada University, Yogyakarta. Special thanks to the promotors Dr. Ir. Arif Kusumawanto, M.T. (Promotor) and IPU, Ir. Agam Marsoyo, M.Sc., Ph.D (Co-Promotor) for the valuable advices.

REFERENCES

[1] (2020, September, 13 2021). *Sekilas SDGs*. Available: http://sdgs.bappenas.go.id/sekilas-sdgs/

[2] B. Setiawan. (2015, September 2021). *Kampung Kota Dan Kota Kampung: Tantangan Perencanaan Kota Di Indonesia*.

[3] U. Grober, "The Discover of Sustainability The Genealogy of Term," in *Theories of Sustainable Development* Judith C. Enderz and M. Remig, Eds. New York: Routlegde, 2015, pp. 6-15.

[4] Zhongming Shi, Jimeno A.Fonseca, and A. Schlueter, "Floor area density and land uses for efficient district cooling systems in high-density cities," *Sustainable Cities and Society*, vol. 65, no. 102601, 2021.

[5] N. N. Amelia, "Efisiensi Energi Operasional Kawasan Mangkubumi Yogyakarta Menggunakan Simulasi Urban Modelling Interface," Master, Arsitektur dan Perencanaan Universitas Gadjah Mada, Yogyakarta, 2021.

[6] Siregar, Z., Tarigan, N. M. R., & Sahnan, M. (2022). Strengthening Human Resources Through Introduction and Stunting Prevention. ***East Asian Journal of Multidisciplinary Research***, 1(7), 1221-1228.

[7] S. Herlambang, W. K. Astuti, and R. Suryadjaja. (2022) Contested volumetric space: floor area uplift policy in Jakarta. *Bulletin of Geography. Socio-economic Series*, . 101-112.

[8] M. Cheng, H. Qin, K. He, and H. Xu, "Can floor-area-ratio incentive promote low impact development in a highly urbanized area?—A case study in Changzhou City, China," *Frontiers of Environmental Science & Engineering,* vol. 12, no. 8, 2017.

[9] Sarkum, S., Syamsuri, A. R., & Supriadi, S. (2020). The role of multi-actor engagement. ***Journal of Open Innovation***: Technology, Market, and Complexity, 6(4), 176.

[10] M. A. Noble, A. G. Noble, and F. J. Costa, "Floor area ratio as an urban development tool The case of West Palm Beach," *Land Use Policy,* vol. 10, no. 2, 127-139 1993.

[11] A. P. Association. (2023, 6 August). *Floor Area Ratio : PAS Report 111*. Available: https://www.planning.org/pas/reports/report111.htm

[12] A. Cheshmehzangi and A. Dawodu, "Towards a Sustainable Energy Planning Strategy: The Utilisation of Floor Area Ratio for Residential Community Planning and Design in China," *Sustanable Cities*, vol. 3, 2021.

[13] Supriadi, ., Dalimunthe, R. F., Lumbanraja, P., & Tarmizi, H. B. (2021). The Antecedent Of Educational Staff Contextual Performance In Medan City Private Universities. Archives of Business Research, 9(2), 316–338. https://doi.org/10.14738/abr.92.9817

[14] Khoirunurrofik, "Strategic Interaction Between the Agglomeration of High-Rise Buildings and the Economy of DKI Jakarta," ***International Journal of Sustainable Development and Planning***, vol. 17, no. 5, pp. 1449-1459, 2022.

[15] Yogyakarta, "Perda DIY No. 2 Tahun 2010 Tentang Rencana Tata Ruang Wilayah Kota Yogyakarta," ed, 2010.

[16] Sri, R., Mahdi, F., Julkarnain, J., Kurnia, H. N. T., & Habibie, A. (2022). Intellectual capital and islamic corporate social responsibility on the financial performance of sharia commercial banks in Indonesia. In E3S Web of Conferences (Vol. 339, p. 05003). EDP Sciences.

[17] S. D. LAB. (2023, 6 August). *Urban Modeling Interface 3.0*. Available: http://web.mit.edu/sustainabledesignlab/projects/umi/umi_about.html

[18] M. A. (https://architecture.mit.edu). (2021, October 24). *Project Urban Modeling Interface*. Available: https://architecture.mit.edu/building-technology/project/urban-modeling-interface

[19] Yusrita, Y., Fahmi, N. A., Yudha, T. K., & Nasution, I. (2020). Capabilities, Commitments and Effect on the Competitiveness of Small and Medium Enterprises (SME) in Medan. ***Budapest International Research and Critics Institute-Journal (BIRCI-Journal)***, 3(3), 2442-2450.

[20] C. F. Reinhart, J. Alstan Jakubie, Timur Dogan, and T. Rakha, "UMI - An urban simulation environment for building energy use, daylighting and walkability," in *Proceedings of BS2013: 13th Conference of International Building Performance Simulation Association, Chambéry, France, August 26-28*, France, 2013.

[21] N.Hamidah, R. Rijanta, Bakti Setiawan, and M. A. Marfai, "Kampung Sebagai Model Permukiman Berkelanjutan Di Indonesia," *INERSIA,* vol. 12, no. 2, pp. 114-124, 2016.