
Spatial Analysis of Slum Levels and Settlement Planning Based on Environmental Vulnerability in The Babakan Raya Area, Babakan Village, Dramaga District, Bogor Regency

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Abstract: The redevelopment of the slum area in Community Unit CU (Rukun Warga/RW) 07 Babakan Raya, Dramaga District, is a strategic step to reduce slum conditions while improving the quality of the area's infrastructure. This study aims to identify and analyze the existing slum conditions based on basic infrastructure, land use, building density, and environmental quality, and to develop a spatial planning concept based on spatial analysis to produce an adaptive and sustainable site plan. The methods used include a physical survey in the field, involving 81 respondents through crowdsourcing, and a Weighted Overlay analysis based on the criteria outlined in the Regulation of the Minister of Public Works and Public Housing No. 14/PRT/M/2018. The results showed that 56% of respondents identified building quality as the main factor contributing to slum conditions, followed by drainage problems at 23%. The spatial analysis identified a severe slum area of 9.220 m² located in the southern part of CU 07, while the mild slum area reached 61.210 m². The projected population of Babakan Raya in 2044 is estimated to accommodate 6.500 people, with a density of approximately 573 people per hectare. As a technical response, a spatial plan for the development of the area was prepared in accordance with SNI 03-1733-2004 to improve building layout, drainage systems, and environmental quality in the future. Implementation of this plan is expected to create a healthier, safer, and more sustainable residential environment.

Keywords: Area planning, Babakan Raya, Geographic Information System, slum.

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1. Introduction

Settlements are the most tangible representation of human interaction with space, where social, economic, and environmental aspects mutually shape the patterns of community life [1]. In the context of regional development, the quality of settlements not only reflects the well-being of residents but also serves as an indicator of the effectiveness of spatial and environmental governance. However, when settlement development proceeds unchecked and is not balanced by an adaptive planning system, the phenomenon of slum formation emerges—a spatial condition characterized by simultaneous physical, social, and ecological degradation [2].

The issue of slums is a top priority on the sustainable development agenda. Based on the 2020–2024 National Medium-Term Development Plan (RPJMN),

the government aims to eliminate slum areas through the Slum-Free City Program (KOTAKU), which is grounded in the principles of Sustainable Human Settlements. This approach focuses not only on physical improvements but also on strengthening the social, economic, and institutional resilience of communities. The greatest challenges arise in areas located in transition zones, where economic, educational, and social activities are growing rapidly without being matched by adequate infrastructure capacity [3].

Based on Bogor Regent Decree No. 663/141/KPTS/PER-UU/2019, there are 13 subdistricts identified as slum areas, one of which is Dramaga Subdistrict [4]. Babakan Raya is an area within Dramaga Subdistrict that directly borders the IPB University Dramaga Campus, which also serves as a residential area and a hub for local economic activity. The Babakan Raya area exhibits the dynamics of a transitional settlement facing significant spatial pressure, in line with the increasing number of migrants, particularly IPB University students residing in the area through boarding houses and rented accommodations [5].

In this context, understanding the issues surrounding slum settlements in Babakan Raya cannot be separated from the perspective of the communities directly affected by environmental impacts [6]. Environmental vulnerabilities in this area are reflected in suboptimal drainage conditions, limited domestic waste management, and a lack of open spaces that serve as ecological buffers, all of which significantly affect residents' comfort and health [7]. Participatory mapping is a crucial approach for identifying these conditions in greater detail and within their specific context, as it captures the perceptions, experiences, and local knowledge of the community regarding vulnerable areas and environmental issues that are often overlooked in formal spatial data [8].

A number of previous studies have examined the characteristics of slum settlements using both spatial and participatory approaches. Wibowo and Sarkowi (2022) [8] emphasize the importance of participatory mapping in identifying environmental vulnerabilities based on community perceptions, while Muta'ali and Nugroho (2019) [9] and Wihasti and Pramono (2025) [10] demonstrate that the morphological structure of settlements is closely linked to the quality of accessibility and spatial efficiency. However, most of these studies still focus on identifying and analyzing existing conditions without integrating the results of spatial and participatory analyses into the formulation of practical area planning concepts. Therefore, research is needed that not only maps the level of urban decay but also translates it into contextual area planning for transitional settlement areas such as Babakan Raya. This research is important because area planning that is not based on levels of environmental vulnerability risks resulting in interventions that are not well-targeted; thus, a spatial approach is needed that can identify priorities for action in a more measurable, adaptive, and sustainable manner.

Based on this background, this study addresses the question of the current state of basic settlement infrastructure in the Babakan Raya area, Babakan Village, Dramaga Subdistrict, Bogor Regency, as assessed using the indicators outlined in Ministry of Public Works and Public Housing Regulation No. 14/PRT/M/2018, as well as community perceptions of vulnerability through a participatory mapping approach, as well as how the spatial distribution and classification of slum levels, along with physical building factors, contribute to the decline in environmental quality in the area. The urgency of this study lies in the high spatial pressure on the area as a transitional zone directly bordering a higher education campus, which has the potential to experience increased density and environmental degradation if not addressed through planning based on measurable spatial analysis. This study aims to identify and analyze the existing conditions of slum settlements spatially, as well as to develop a land-use suitability-based area planning and development concept to produce an adaptive and sustainable settlement site plan.

2. Methods

2.1. Location and Materials

This study was conducted from December 2024 to April 2025. The study site was located in the Babakan Raya area, Babakan Village, Dramaga Subdistrict, Bogor Regency, West Java. The study area covers 11.34 hectares. The tools used in this study included a laptop equipped with ArcMap 10.4.1, QGIS Desktop 3.44.2, Google Earth Pro, SketchUp Pro 2021, AutoCAD 2023, Microsoft Office, and Ushahidi. Primary data was obtained through participatory mapping or crowdsourcing and direct observation of slum area parameters, namely buildings, neighborhood roads, drainage channels, wastewater management, waste management, fire protection systems, and green open spaces. Meanwhile, the secondary data used includes the boundaries of the Babakan Raya area, Dramaga Subdistrict, Bogor Regency, West Java Province; the 2024-2044 Bogor Regency Spatial Plan (RTRW) document; and Ministry of Public Works and Public Housing Regulation No. 14 of 2018.

2.2. Research Procedures

This study was conducted in accordance with several regulations established by relevant government agencies, namely Law No. 1 of 2011 on Housing and Residential Areas, Regulation of the Minister of Public Works and People's Housing No. 14/PRT/M/2018 on Improving the Quality of Slum Housing and Slum Settlements, and Decision of the Regent of Bogor No. 663/141/KPTS/PER-UU/2019 on the Designation of Locations for the Management of Slum Settlements in Bogor Regency.

The research process began with the collection of primary data from 81 local residents and students who participated in mapping via the Ushahidi crowdsourcing platform to identify the locations and primary factors contributing to slum conditions in the Babakan Raya area, particularly in CU 07. Next, infrastructure was identified to assess the existing conditions of the study site, referencing the criteria for slum settlements outlined in Ministry of Public Works and Public Housing Regulation No. 14/PRT/2018, and to validate residents' perspectives through the participatory mapping conducted earlier. These results were used as scores for each parameter to create a slum suitability map, taking into account several parameters: land cover, flood risk, ground elevation, slope gradient, and land suitability. These five parameters were weighted to determine slum suitability, as presented in **Table 1**.

Table 1 Slum suitability parameters

Num	Parameter	Class	Value/Description	Score
1	Land Cover	Very Good	> 30 %	4
		Good	20 – 30 %	3
		Moderate	10 – 20 %	2
		Poor	< 10 %	1
2	Elevation	Very Low	< 500 masl	4
		Low	500 – 749 masl	3
		High	750 – 1000 masl	2
		Very High	> 1000 masl	1
3	Slope Gradient	Flat	< 10 %	4
		Gentle	10 – 15 %	3
		Moderate Steep	16 – 20 %	2
		Steep	> 20 %	1

Num	Parameter	Class	Value/Description	Score
4	Flood-prone area	No Flooding	Within a one-year period, the land is never flooded for more than 24 hours	4
		Rare	Within a period of less than one month, flooding lasting more than 24 hours occurs irregularly	3
		Frequent	For 2–5 months a year, the area is regularly flooded for more than 24 hours	2
		Routine Flooding	For six months or more, the area is routinely flooded for more than 24 hours	1
5	Land Suitability	Very Suitable	116 - 140	
		Fairly Suitable	89 - 115	
		Marginal	62 - 88	
		Unsuitable	35 - 61	

The plan for the redevelopment of slum settlements in the Babakan Raya Area was formulated based on data from participatory mapping and infrastructure identification to reduce slum conditions and improve the quality of facilities in the Babakan Raya Area. The transformation of this area is outlined in site plans and technical drawings that adhere to SNI 03-1733-2004 regarding Procedures for Housing Environment Planning. As an evaluation step, the results of the design will be analyzed by comparing current field conditions with the performance standards of the City Without Slums (KOTAKU) program as stipulated in Ministry of Public Works and Public Housing Regulation No. 14/PRT/M/2018 [11].

3. Results and Discussion

3.1. General Conditions of the Babakan Raya Area

The Babakan Raya area, encompassing CU 07 with a total area of 11.34 hectares, is located in Dramaga Subdistrict, Bogor Regency, West Java Province, at coordinates approximately 6°33'22.26" S and 106°43'35.08" E. Physically, the Babakan Raya area is characterized by lowlands with an elevation of 163 meters above sea level, a daily temperature of around 28°C, and high annual rainfall of 3,500–4,000 mm/year according to the Central Statistics Agency (BPS) 2025, placing it in the tropical rainforest climate category. In terms of administrative boundaries, Babakan Village borders Balumbang Jaya Subdistrict (Bogor City), as well as other villages in Dramaga Subdistrict such as Ciherang Village and Cikarawang Village.

The CU 07 Babakan Raya area, located in Babakan Village, Dramaga, is characterized by a building layout dominated by multi-story structures with very tight spacing between buildings, resulting in insufficient sunlight penetration and suboptimal air circulation (unsanitary conditions). Additionally, the road network lacks sidewalks and road shoulders and is only 2 meters wide, which does not comply with SNI 03-1733-2004. This is also a contributing factor to the poor living conditions resulting from the extremely narrow spacing between buildings.

Basic infrastructure challenges in this region are further exacerbated by a drainage system that lacks integration and suffers from discontinuities between channels. As a result of these disconnected drainage channels, water often accumulates on the road surface, reducing the durability of the pavement and the aesthetic appeal of the environment [12]. Visually and functionally, existing channels have degraded due to the growth of moss and wild vegetation, which significantly impedes water flow to the point where water stagnates [13]. Although a waste management system is in place through routine collection, the

complexity of land use planning and stormwater infrastructure still requires technical intervention to create a more livable residential environment.



Figure 1 Current condition of infrastructure in RT 07 Babakan Raya

3.2. Main Factors Contributing to Slum Conditions

In addition to direct observation of the existing infrastructure conditions, participatory mapping was also conducted with 81 respondents, consisting of students living in dormitories in Babakan Raya, students familiar with the Babakan Raya area, local residents, the head of CU 07, and shop owners in Babakan Raya. The participatory mapping aimed to identify community perceptions regarding the main factors contributing to urban blight in the Babakan Raya area. Each respondent selected one of seven indicators of urban decay based on Ministry of Public Works and Public Housing Regulation No. 14/PRT/M/2018, namely buildings, neighborhood roads, drinking water supply, drainage, wastewater management, waste management, and fire protection. The mapping results are presented in the graph in **Figure 2**.

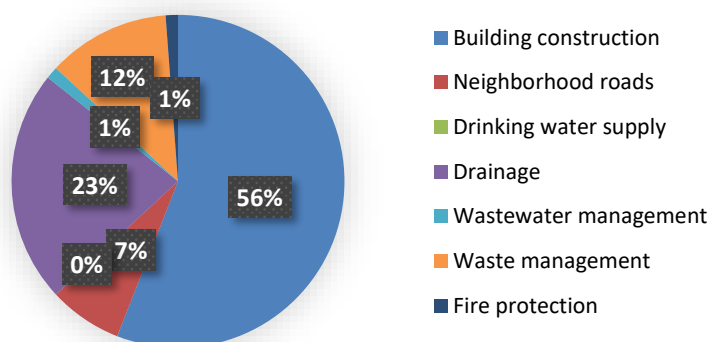


Figure 2 Graph of participatory mapping results

The results of participatory mapping involving 81 respondents in CU 07 Babakan Raya indicate that community perceptions of the seven indicators of urban blight vary. Figure 2 shows that the majority of the community, namely 47 people (56%), assessed that the condition of buildings is the main cause of slum conditions in the Babakan Raya area. This indicates that building quality aspects such as housing density, non-permanent building structures, and non-compliance with spatial planning are dominant issues in the area.

The neighborhood road indicator ranked second, with 6 respondents (7%). These responses indicate that there are still narrow, damaged, and potholed roads—or roads impassable to four-wheeled vehicles—which affect accessibility and the quality of the residential environment. Meanwhile, the drainage indicator was selected by 19 respondents (23%), indicating that the rainwater runoff control system is suboptimal. The indicators for wastewater management, waste management, and fire protection were selected by 1, 10, and 1 respondents, respectively.

Although the percentages are not dominant, these three aspects still require attention, given that inadequate wastewater management directly impacts environmental health. As for the drinking water supply indicator, it was not selected by respondents, which likely reflects that the community does not view this parameter as an urgent issue in CU 07 Babakan Raya. Nevertheless, the availability of clean water infrastructure remains crucial in supporting the overall resilience of the residential area.

Overall, these findings indicate that physical factors and basic infrastructure—particularly buildings and neighborhood drainage—are the top priorities in the community's perception of urban blight in CU 07 Babakan Raya. Therefore, urban planning policies should focus on improving housing quality, regulating density, and upgrading drainage and roads.

3.3. Slum Conditions

An analysis of slum suitability in the Babakan Raya area was conducted using the weighted overlay method, taking into account indicators from the results of the participatory mapping that had been carried out. The weighted overlay method is a spatial analysis approach that combines various variables to produce an index map reflecting priorities, risk levels, or the suitability of an area [14]. In principle, this method is based on the assumption that an environmental phenomenon, such as slum formation, is not caused by a single factor, but rather by a combination of many interacting physical, social, and infrastructural characteristics [15]. Each variable has a different influence, and it is these influences that are translated into a weighting system.

Table 2 Classification of slum conditions

Num	Classification	Area (m ²)
1	Non-slum	42.930
2	Midly slummed	61.210
3	Severely slummed	9220

The results of the weighted overlay analysis in CU 07 Babakan Raya yielded a classification into three categories: non-slum, mild slum, and severe slum. Based on area data, the non-slum area covers 42,930 m², the mild slum area covers 61.210 m², and the severe slum area covers 9.220 m².

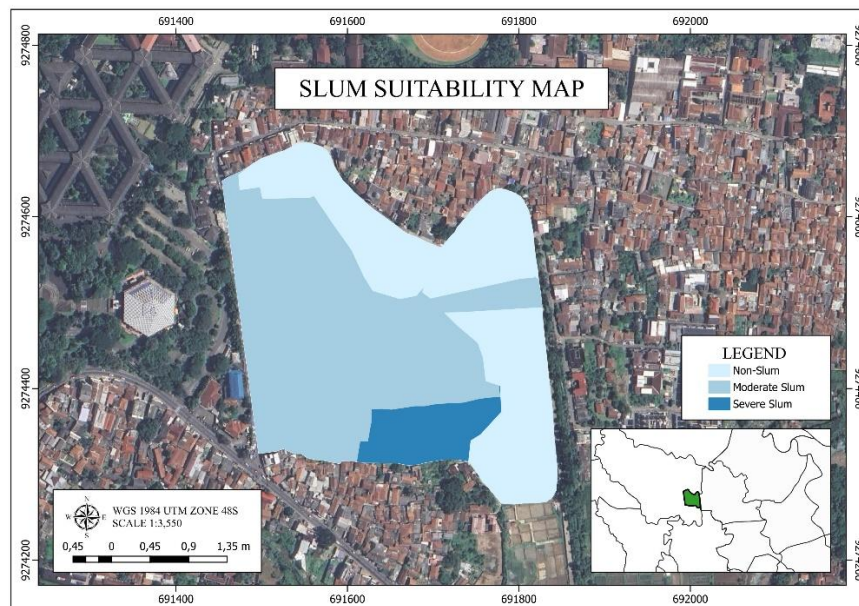


Figure 3 Slum suitability map

The spatial distribution on the Slum Suitability Map in CU 07 reveals quite contrasting variations in environmental quality across each administrative zone. The northern part and portions of the eastern side of the area are dominated by the “Non-Slum” category, indicating better building order and infrastructure. Conversely, the central to western zones begin to fall into the Moderately Slummed classification due to higher housing density and the deterioration of basic infrastructure. This transitional condition reflects the need for environmental infrastructure maintenance to prevent slum levels from worsening in the future.

The most critical conditions are identified in the southern part of CU 07, classified as Severely Slummed. The high concentration of slum conditions in this area indicates the urgency of more intensive physical interventions compared to other zones. The determination of these categories refers to technical indicators established in the Kota Tanpa Kumuh (KOTAKU) program standards as well as Ministry of Public Works and Public Housing Regulation No. 14/PRT/M/2018.

The results of this weighted overlay analysis indicate varying levels of urgency in addressing urban blight across each zone within CU 07 Babakan Raya, using an approach that takes into account the area’s function, physical conditions, and the socioeconomic aspects of the community.

3.4. Population Projections for the Babakan Raya Region

According to information from the Village Secretary, the population of CU 07 Babakan Raya in 2026 is recorded at 6.113 people, consisting of 613 local residents and 5.500 students renting rooms. Using the exponential projection formula, the population in 2044 is estimated to increase to 28.887 people, consisting of 678 local residents with a growth rate of 0,0056 and 28.209 students with a growth rate of 0,09. The population projection is carried out up to the year 2044, referring to the implementation period of the Regional Spatial Plan (RTRW) of Bogor Regency for 2024–2044, which serves as the primary guideline for long-term spatial development planning in the area. Thus, the projected population density in 2044 will reach 2.547 people per hectare. This places the area in the “very high density” category according to SNI 03-1733-2004 standards. This extremely high density figure indicates extraordinary demographic pressure on the relatively limited residential space in CU 07. This massive population concentration undoubtedly has a direct impact on the decline in environmental carrying capacity, particularly regarding sanitation systems, waste management, and the availability of open spaces [16].

3.5. Residential Building Planning

According to information obtained from the Village Secretary, CU 07 Babakan Raya currently accommodates approximately 321 households, with an average household size of one to two individuals. To support long-term planning for permanent housing development, a projection of household growth was conducted up to the end of the Regional Spatial Plan (RTRW) period in 2044. The results indicate that the number of households is expected to increase to 321, corresponding to an estimated 678 permanent residents. It is important to note that this figure represents only the permanent (formal) population and excludes the presence of student migrants who reside temporarily in the Babakan Raya area. The existence of this non-permanent population further contributes to the actual density of the area. As a result, the overall population pressure on land and infrastructure is likely to be higher than the projected figures.

In response to these conditions, it is essential to maintain a balanced spatial composition and ensure compliance with applicable regulations through controlled population growth. Without proper limitations, the increasing population will significantly raise the demand for housing and supporting infrastructure. This condition will inevitably lead to higher building density and more intensive land use within a limited area. Consequently, the proportion of Green Open Space (RTH) may decrease below the minimum required threshold. According to prevailing spatial planning regulations, the provision of RTH must reach at least 30% of the total area. Failure to meet this requirement would adversely affect environmental quality, including reduced air circulation, increased urban heat, and decreased overall livability.

Therefore, a population control strategy is proposed to ensure that spatial development remains sustainable and well-managed. In this plan, the maximum population is limited to 6.500 residents to prevent excessive land use intensity. This threshold is determined based on the standard space requirement of 9,6 m² per person in accordance with SNI 03-1733-2004. By applying this standard, land allocation for residential use can be distributed more proportionally. At the same time, sufficient space can be reserved for Green Open Space (RTH) and other supporting facilities. Ultimately, this approach supports the creation of a more balanced, organized, and environmentally sustainable settlement structure.

Furthermore, the current condition of buildings in CU 07 Babakan Raya remains suboptimal in terms of spatial organization. The availability of basic facilities and infrastructure has not yet adequately met the needs of both permanent and seasonal residents. This situation reinforces the urgency of implementing a comprehensive redevelopment strategy. Through proper spatial restructuring, both environmental quality and functional efficiency can be significantly improved. The proposed physical and spatial design interventions are presented in the site plan shown in **Figure 4**. This design serves as a concrete representation of the planned redevelopment approach in the study area.

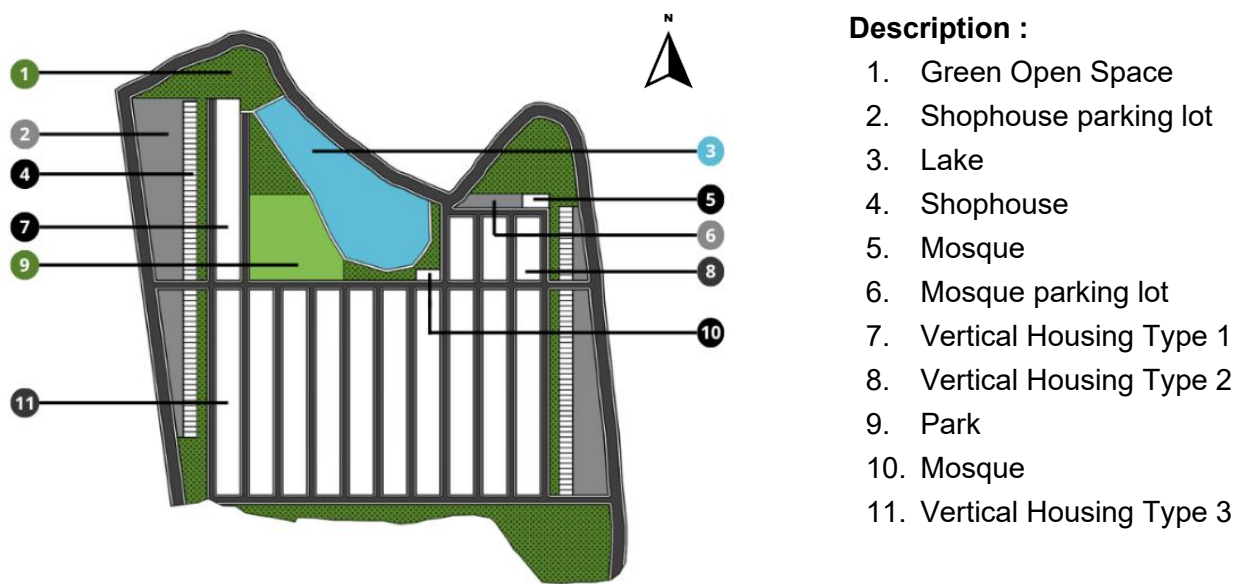


Figure 4 Site plan for the development of CU 07 Babakan Raya

The site plan for CU 07 Babakan Raya was developed in accordance with the land use guidelines set forth in the 2024–2044 Bogor Regency Spatial Plan, which designates the area as a residential zone. Housing for local residents is located in an area closer to the main road to facilitate access to daily activities, while student housing blocks are placed at the rear of the area to reduce traffic density and maintain the comfort of the residential environment. Additionally, the provision of Green Open Spaces (GOS) in the area's design accounts for 32,57% of the total area, thereby meeting the minimum standard of 30%. The park is situated in the center of the area to ensure equitable access for all residential blocks and to serve as a space for social interaction and an ecological buffer for the area.

4. Conclusion

Based on an analysis of the conditions in CU 07 Babakan Raya, it can be concluded that this 11.34 hectare area faces a serious challenge in the form of extremely high population density, which is projected to reach approximately 2.547 people per hectare by 2044. Therefore, a population control strategy is proposed to ensure that spatial development remains sustainable and well-managed. In this plan, the maximum population is limited to 6.500 residents to prevent excessive land use intensity. The results of spatial identification and community perceptions indicate that the quality of buildings (56%) and the drainage system (23%) are the primary factors contributing to slum conditions in the area. The most critical area was identified on the southern side of the zone, classified as severely slummed with a coverage area of 9.220 m². Uncontrolled growth of vertical housing has reduced sunlight penetration and air circulation within the residential area, necessitating a restructuring intervention through the development of a more planned site plan. The planning of this area is aimed at improving the quality of basic infrastructure and supporting the housing needs of a projected 321 households in the future, in accordance with SNI 03-1733-2004 and Ministry of Public Works and Public Housing Regulation No. 14/PRT/M/2018.

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