Violation factors of the building coverage ratio:
A study in Trimulyo Genuk, Semarang, Indonesia

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Abstract. Excessive Building Coverage Ratio (BCR) defined as shutting of land that is supposed to be exposed, may have a significant impact on water infiltration, eventually leading to a higher risk of both drought and flooding. The objective of this research is to find the causative factors of violated BCR in a highly flood-prone area. Using a cross-tabulation method, the cause of the violation of the BCR divided by external and internal factors. External factors, such as the absence of sanctions, large area of land owned and less understanding on what BCR is, had a negative correlation with violations. On the other hand, internal factors, such as income, household enterprises, and household size, had a positive correlation with BCR violations. The conclusion of this study that there have been insufficient propagation to the public about the BCR, resulting in most people being indifferent to, or unaware of, the disadvantages and dangers arising from the violation thereof.

Keywords: Density of residential area, external and internal factors, tidal overflow, urban planning.

1. Introduction

The house is a basic need, functioning as one of the motivations to acquire a better life quality, in addition to physical needs such as food and clothing. This basic need that is structural in nature, as part of improving the well-being of the people [1]. Thus the housing and settlement development program is a part of efforts to meet one of the primary human needs, given its significant role in human life. Historically, the housing development was originally carried out independently, progressively developed to form communities, and ultimately shaping as settlements, such as villages, towns and cities. In this process, much work is done by governments and urban development organizations, in addition to the housing construction carried out by the community [2].

Poerba identifies three actors of housing development: the government (public sector), the dwellers (private sector) and their associations (community sector) [3]. The implementation of the housing construction for low income people in Indonesia is carried out by the government and society itself [4]. Rapid economic growth, causing the level of urbanization to greatly increase, starts to bring various complications to environmentally vulnerable town areas. The space in towns is very limited, so the growth of many new settlements is emerging in the suburbs. With an increase of land prices,
even such suburb location dwellings are prone to be tight, with an area of the lot being limited, the
distance between the buildings becoming too small, causing uncontrollable growth of density in many
residential areas.

Anticipating this, the government started to control the density of residential areas through
instruments such as regulations of Building Coverage Ratio (BCR; see Figure 1) as outlined in the
Spatial Plan of the City and in the process of permitting construction of houses through Building
Permit (IMB = Ijin Mendirikan Bangunan) [4]. But in reality these measures are still being largely
violated. Such BCR violations need to be investigated, because they could result in the closing of land
that must be exposed. Covering the land extensively with buildings has an adverse effect on water
infiltration. The loss of water infiltration may lead to a drought and a flooding of the unexposed area.
To investigate this phenomenon, a research was conducted based on the factors contributing to the
violation of BCR in the outskirts of the residential area of Semarang city, Indonesia, especially in the
Genuk District, Trimulyo village. Results of this study could be regarded as recommendations for
further action of the Municipality in order to optimize the existing rules in the determination of BCR
standard. This location was selected due to its rapid growth, being close to the sea shore, regular sea
water tide inundations, flat terrain – in conjunction with these factors, violated BCR may have
extremely adverse effects on the dwellings in the area.

Figure 1. Description of BCR on a building site.

2. Research Site
The research was conducted in the Trimulyo village, Genuk District of Semarang City, Indonesia in
three neighborhood associations (NA): NA-4, NA-6, and NA-7 (Figure 2). These three NAs were
chosen due to a large number of houses (N=1,109; [Semarang, 2018]). This area is very crowded,
almost none of the houses have a yard, the latter commonly turned into a building, resulting in
constant flooding. All NAs are crossed by a small river (Sringin River) that serves as a disposal of rain
water (drainage) and as well as domestic sewerage, so that changes in the BCR values of individual
dwellings would affect overall water runoff discharge in the area. Rain water runoff from each yard is
thrown into a small channel then into the creek. During the rainy season, the river flow is very heavy,
but on the contrary, during the dry season there is a sea water tide, and in those settlements that always have inundation every season, the river gets heavily polluted resulting in an unpleasant smell. Objects being studied are homes featuring violation of the provisions of the BCR defined in the City Master Plan, wherein the magnitude of allowed BCR is 60 %, meaning that every home may have a maximum area of 60 % covered, and should provide an open space for at least 40 % of the total site. In order to find out the reasons for these violations, violators were selected in this study to facilitate prevention in the future.

Figure 2. Research Location: Trimulyo Village, Genuk District, Semarang City, Indonesia.

Figure 3. Original form of the housing in Indonesia with standard BCR 60/40 ratio.
3. Research Purposes
It is known that changes in the built area would lead to increased water runoff. The actual change itself is a violation of the provisions of the building code that has been set. The purpose of this research is to find factors that cause violation of BCR, and calculate an approximate runoff in the residential areas of Trimulyo village in Genuk district, Semarang city, Indonesia.

4. Methodology
The research uses quantitative methods of cross tabulation analysis. Data were collected from violators of the allowed BCR, aiming to understand reasons for such violations. The data in this study can be subdivided into primary data and secondary data. Primary data were obtained directly from the field, either through census or sampling, while secondary data were obtained from sources that have been published.

The data collection phase aims to obtain primary data required as an input at the analytical stage. Secondary data were obtained from the relevant agencies with technical documentation, collected mainly in the form of legislation relating to the provisions of BCR. The primary survey was conducted to obtain data directly from the field, represented as a direct observation in the field with the following data collection techniques:

i. Direct observation in the field with an aim to equate the information obtained from secondary data with conditions in the field, with tools such as digital cameras and floor plans and maps (Figure 4).

ii. Distribution of a questionnaire which is a technique of data collection where the respondent is given a list of questions to be answered. In the questionnaire respondents were asked to choose one of the alternative answers that have been provided if the question is closed, and create its own alternative answers if the question is open. Questionnaires were distributed randomly to 100 people whose houses had a violation of the BCR. Collected data were analysed using cross-tabulation method to evaluate categorical factors contributing to BCR violation; the degrees of violation were correlated with ordinal factors using oneway ANOVA.

5. Literature Review
The term 'house' generally refers to the function of protecting against natural disturbances, whereas the term 'home' is commonly used in psychological, social, and cultural contexts. Based on the meaning as a place to settle down, changes in the shape of the house is a commonplace. Housing construction is typically viewed in a materialistic context, commonly ignoring its relationship with the environment.
and culture which is made up of many complex elements, including religion, politics, customs, languages, tools, clothing, buildings themselves, and works of art [5]. The change in shape of a building cannot be separated from the influence of the development function, construction technology, materials, and associations with the natural environment. The change in shape of the building also consists of a change in form (shape of the roof, structure, walls, floors, doors and window shapes), and color. Numerous studies have revealed that the change occurred because of growing form of home building functions, and the owner's social conditions, which examined changes in the form of developing ethnic Chinese, Arabic and Malay buildings in Makassar. One study concluded that the change in space, form, color, and ornamentation of the building appeared due to the cultural and economic features of the owners.

Research conducted by Dewiyanti [6] found that certain changes in the fishermen settlement Bajoe houses occurred because of fluctuations of local culture and economy; namely, they altered the function of a house from its original role of fishing equipment warehouse, turning instead into a commodity place grocery service for the daily needs of local residents, hence economic motives dictated changes in the function of a room. The changes in the form of a given house are very dependent on the conditions of the owners, the physical aspects of the living environment, and social culture embraced. Smith concluded that the benefits of changes in the shape of a house is to prevent the worsening of its appearance, which also helps increase its leasing potential. Also, the number of families living in a house contribute significantly to changes in its shape.

Changes in the shape of a house is a part of the process of inhabiting the house associated with the residents’ attitude, especially their view of the function and the value of their house, occupants’ perception of their house, and motivation to own a house. Houses can be conceptualized in two forms: the house as a physical structure, and the house as a process of inhabiting activity [7]. Any change to the shape of the house will change its connection with the environment; this change can be positive or negative. Positive changes entail the ability of the environment to be more empowered and sustainable, while negative changes cause the opposite, making a given house a burden on the sustainability of environmental functions. Settlement location can be good or bad according to natural physical factors. Physical factors are: topography, water supply, possibility of inundation or flooding, landslides or other rock mass movement, erosion, soil bearing capacity, active fault zone, and the content of toxic gases [8]. In Semarang, for example, a good area for settlements is located in the southern part of the city, because there is no flood possibility, and the area has much greenery.

There are commonly two possible causes of flooding: (i) natural events, such as intensity of rainfall, topography, and natural silting; and (ii) human activity, such as population density, and poor drainage network [9]. In a rational method of Chow [9] explained that to calculate the debit runoff of the rain, the following formula can be used: \( Q = CIA \), where \( Q \) is debit runoff, \( C \) is runoff coefficient, \( I \) is intensity of rainfall, and \( A = \) catchment area of rainwater. This formula shows that if the value of \( C \) increases, the \( Q \) will also go up, if the conditions of \( I \) and \( A \) are considered constant.

Flooding can occur due to human activity (HA), on the basis of natural events (NE), or due to a combination thereof (Figure 5). In the category of HA in the rational method of Chow, it includes the value of \( C \) and \( A \). While \( A \) originally appears a natural feature, humans may change the value, typically in agreement with the river flow. Hence, \( A \) is represented by two dimensions with NE and HA components: given that \( Q = f(C, I, A) \), it can also be shown that \( Q = f(NE, HA) \). Notably, human activity is preceded by an increase in the number of people (residents). Such increase entails surge of goods and changes in land use. In turn, this causes litter to increase and building area to expand. Littering may cause blockages, area expansion may reduce the amount of groundwater recharge, both of which can lead to increased risk of flooding. Violation of allowed BCR may act as a significant contributor to this problem.
Figure 5. Relationship between flooding, natural events and human activities [9].

Occurring house changes generally expand the building area horizontally and often violate allowed BCR, causing a reduction of open space for rainwater infiltration. There are two kinds of floodings that occur in Trimulyo: flooding due to rain, and flooding due to high tides. Because there is only a limited open space for water infiltration, floodings usually last a long time and the inundation levels are high.

6. Results And Discussion

6.1. Result of Research

Those respondents who knew the BCR rules, when asked why they committed violations, stated the following (Table 1). The majority of them received no sanctions. Many pointed to large numbers of family members, some referred to the need to store the property (cars, motorcycles), many simply followed what was done by a neighbor, while others did it to provide sufficient space for the community meetings, which is done from house to house every month; the least common justification was for the needs of business space.

| Justification of Violations                      | Fraction (%) |
|-------------------------------------------------|--------------|
| No sanctions received                           | 21.7         |
| Following the neighbors                        | 17.4         |
| Many family members                            | 19.6         |
| Space requirements for businesses              | 9.8          |
| To store the property                          | 19.6         |
| Broad space for community meetings             | 12.0         |
| **Total**                                      | **100.0**    |

Negative correlations (**P < 0.01, F-test) was found between the BCR violation and the implementation of sanctions, knowledge of the BCR rules, and width of land (Table 2).
Table 2. Negative correlations of BCR violations.

| Information               | R    |
|---------------------------|------|
| Implementation of sanctions | -0.898 |
| Knowledge of BCR           | -0.527 |
| Width of land              | -0.676 |

Income and household size showed a positive correlation to violations of GBCR ($P < 0.01$, F test). Also, positive correlations were found between violations and the number of family members (Table 3).

Table 3. Positive correlations of BCR violations.

| Information             | R    |
|-------------------------|------|
| Income                  | 0.702 |
| Number of family members | 0.729 |

There are 1109 houses in Trimulyo, each of them has an area of about 70 m$^2$. The total width of the area of the land is about 77630 m$^2$. The changes of increasing building coverage is 19922 m$^2$, meaning that there could increase the water runoff in the studied area by 26%.

6.2. Discussion

The findings can be grouped by internal aspects (such as the need for additional space), and the external aspects (the implementation of regulations regarding the BCR). The internal aspect included associations with the space requirement, income of residents and the number of family members. Some of these problems could be solved by extending the building vertically without changing the existing provisions in the BCR, this might work particularly well for families with higher income.

Residents with many family members and those with the need for space for business activities, could meet their requirements through the supply of homes with a site that is relatively wide, even if the quality of the building is slightly lower, and by making a reduction in the number of rooms to have more open space that could also reduce the cost of building materials. In regard to the external aspects (the regulation of BCR), increasing the awareness is a crucial step in an effort to diminish its violations. The chairmen of the NAs indicated that the officer of the city administration provided minimum information regarding BCR, but none of the NA members were admitted to a meeting to discuss BCR in detail.

Notably, a tradeoff between building coverage and amount of greenery in urban environments precipitated much research around the globe. The various land cover types are needed for different areas, finding certain limits of allowed land cover. In a comprehensive review, a strong and significant inverse relationship between amount of vegetation and total runoff in a large list of urban areas. Much attention is paid to the buildings themselves, suggesting that materials must be flood-resilient [5] and various parts of construction such as floors must be sufficiently protected and elevated [10]. Remarkably, building code regulations receive insufficient attention in many countries around the globe, even in Europe, raising similar concerns to those proposed in this study [11], particularly in light of the changing climate [12, 13] highlighting further significance of this research.

7. Conclusions and Perspectives

i. The deciding factor in BCR violations comes from external and internal factors; external factors had a negative correlation with violations, while internal factors had a positive correlation with violations.

ii. Violations of BCR rules could have a very wide impact on urban spaces, which is apparent in the increased flooding, as well as drought.
iii. Violations occur mainly due to the unfamiliarity with the rules, and the absence of sanctions, especially for the settlements located far from the supervision area.

iv. There has been no dissemination to the public, so most people do not know the disadvantages and dangers arising from the violation of BCR.

v. Trimulyo villages feature an alarming increase in flooding area of around 26 %, caused by BCR violations.

vi. In the future, plan for investigate further areas in Indonesia which are prone to tidal and seasonal flooding. With the advent of novel modeling and analysis methods for e.g. urban building density measurement as well as flood models for individual households and buildings, need to provide with novel tools to continue this kind of research even on a larger scale.

Acknowledgements

The credits to all those who have helped in this study, ranging from village officials, the local citizen association, as well as friends in Semarang city planning office. Also thanks to the friends at the laboratory of city design in the Department of Urban and Regional Planning Diponegoro University who have helped and gave meaningful feedback. Thanks also to the students of D3 program of Urban and Regional Planning Department that helped in conducting the survey. Special appreciation to Wiwik Lestari, Gleb Bezgin, Alfi Afadiyanti, Bagus Al Farazi and Laily R. for the editorial help of this research.

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