

Unraveling the impact of built-environmental self-modification of the local inhabitants in their attempt to reduce the urban flood impact in Grogol, Sukoharjo*

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Abstract. Due in part to climate change impact and the lack of environmental awareness of urban societies, urban flood disasters have increased in both frequency and impacted areas. The inevitable destructive impact is also experienced by urban inhabitants within Grogol District, Sukoharjo, Central Java. Situated within the fast-growing peri-urban area of Surakarta, the geographical condition of the district, which is located in the convergence of Bengawan Solo River and four different streamlet rivers is undoubtedly critical to flood. Since the position of the peri-urban area is along the border of Surakarta City and Sukoharjo Regency, the site is a strategic locus of the main city's urban expansion. However, its border location has made flood-reduction programs challenging to be implemented, due to unclear territorial admiration and distribution. Because of the absence of flood-reduction programs in the area, local inhabitants have been independently developing physical and built environmental modification of their settlements. By analyzing the two-months built environmental fieldwork research in Grogol Sukoharjo, this paper unravels both the success and the conflicting impact of local self-initiative modification in Grogol Sukoharjo. By combining the two-month field observation with the semi-structured interviews in three sub-districts of Grogol, this paper finds that the very pragmatic self-modification taken by the inhabitants results in short-term reductions of flood impact and increases the secure feelings of inhabitants to continue living in their neighborhoods. However, the lack of proper technical supervision from experts and the absence of inter-neighborhood coordination leads to future additional damage on the flood-prone areas of Grogol. The paper also reveals that one pragmatic physical self-modification solution taken by one neighborhood may lead to an extra flood-threat to other neighborhoods.

1. Introduction

Waterway has long had an important role in daily human activity and economics. Water is used for physical human needs, industrial, and agricultural production. Prior to and during colonialism, rivers have had important roles in the economy, transportation of goods and services, as well as human daily needs and mobility. Nevertheless, due to the escalating growth of urbanization and technology, with it bringing changes in economy, settlements, physical infrastructure and culture. With the increasing density of cities due to urbanization, more land is being covered by infrastructures. This condition has greatly reduced the natural capacity to absorb water. The loss recognition to the existence of waterways,



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such as rivers is one of the reasons that trigger more catastrophic natural disasters, especially the escalation of urban flood disasters.

Thanks to the increased frequency of campaigns on the impact of climate change. The existence of waterways has regained attention as an important feature necessary to be integrated into city and regional planning. Today, every agency of the city stakeholders develops concerns in responding to the increased events of urban flood. However, this paper specifically limits the result from observation on the physical responses undertaken by individuals to reduce the impact and risk of urban flood.

The National Government and many local Governments are beginning to reformulate their urban agendas in an attempt to integrate rivers, water, and flood mitigation planning into their spatial planning and urban infrastructural development. Both physical and social scenarios have been formulated to support flood reduction and flood mitigation agendas of the city. Nevertheless, the physical response remains an urgency to be executed in order to deliver immediate urban flood protection. The physical responses have been prepared and taken by the government in the macro context of the city, but there lies a need for support in mezzo-scale that are commonly handled by communities from the district level to neighborhoods and in micro-scale that is handled by individuals from neighborhood level to family.

Insofar, most Indonesian research and scenarios on physical response to floods have been frequently and generally explored in macro-scale, covering both city-scale to district planning scenarios. Ironically, the existing flood-reduction and mitigation planning and solution scenarios have frequently missed to capture the problems of urban floods at a micro-level that covers challenges of flood-reduction response in neighborhoods to the household level. In terms of physical infrastructural solutions to reduce the risk of floods, the macro-scale planning scenarios commonly propose financial support to be delivered to several selected areas of sub-district or neighborhoods based on selected priority areas, depending on the level of their vulnerability. Nevertheless, there is an absence of expert supervision to guide how the aids should be properly used to construct physical infrastructural modifications that can help neighborhoods be more protected from floods. As a result, any physical infrastructural modification in mezzo to micro level have been merely executed based on neighborhoods to individual interpretations. However, without proper supervision from experts, the existing self- modification is sometimes only able to secure the dwellings temporarily.

The provision of flood-mitigation action and scenarios in the urban context of the developing countries have to face a challenge that is generated by the dominant patterns of unplanned and organic settlements which are side by side with the other planned-and-less organic settlements. The logic that structuring the co-presence of those diverse settlements in close distance is commonly difficult to trace. Therefore, a proper scenario to provide both adequate water infrastructures and drainage networks that respond to flood-mitigation strategies are also frequently difficult to realize. As a result, the physical infrastructural scenario of flood mitigation at a neighborhood scale is commonly dependent on the decisive initiative action and scenario of each neighborhood. Therefore, the implemented flood mitigation actions tend to have a high degree of variation and disintegration among each neighborhood in close proximity. Instead of improving the capacity of urban areas to reducing the impact of floods; however, this high-degree of variation and disintegration of the self-flood-mitigation action may lead to damaging the extending environment and other nearby neighborhoods

This research highlights the urban flooding responses that have been taken place at the peri-urban area of Surakarta, particularly at Kelurahan Joyontakan of Surakarta City and at Kelurahan Grogol of Sukoharjo Regency. The fact that the uncontrolled urbanization triggers significant problems related to the increased impact of floods, and the complexity to draw flood-reduction scenarios, have been positioned in crucial attention on this paper. Joyontakan and Grogol, the focus areas of this research, are located at lowland areas where four streamlets of the Bengawan Solo River meet with the main river, and as such is at a high risk of flooding. Due to its strategic position at the busiest intercity main road connecting Surakarta City and Sukoharjo Regency, Joyontakan and Grogol have experienced rapid urbanization within the past twenty years.

Joyontakan is the last sub-district directly adjacent to Sukoharjo periphery; while Grogol is at the border of Sukoharjo, adjacent to Surakarta City. Grogol area was initially a major agricultural area of the Soloraya region. However, Grogol has grown to become the prime area of expansion for Surakarta City within the last decade. The majority of the low-land area has been occupied by real-estate oriented developments, the spread of industrial infrastructures and buildings, as well as the organic expansion of self-built urban kampong following the economic attraction generated by real-estate and industries. Since the aforementioned areas had been free of floods since 1963 to 2007, none had ever been aware on the fact that this area carried potential flood risks due to its location flanked by the Bengawan Solo River and its three streamlets. It was only after the area was suddenly hit by catastrophic flash-floods in 2007 that both government and society were made aware of the flood risk that threatens this area. Due to the wide coverage of the area that has been frequently hit by annual floods in Joyontakan and Grogol, this research tries to limit the focus of observation to within three focus areas that experience the worst damage, which covers a total of ten percent out of the entire Grogol and Joyontakan Sub-district administration areas. They are Joyontakan urban kampongs, Puri Gading and its subdivision housing clusters (including Gading Makmur and Gading Permai), and Nusupan urban kampongs.

2. Methodology

Since Indonesian urban settlements are constructed by collages of both kampongs and modern real-estate housing neighborhoods that coexist and give influence to each other; this research does not attempt to follow the previous conventional urban research which tends to observe the Indonesian urban reality in parcels of completely fragmented and separated settlements. This paper does not select one particular study focus such as only kampong, only housing or only a particular community in the research area, but instead this paper attempts to show the influence among the communities (both who live in kampongs and in housing estates) and their flood-risky living neighborhoods, which coexist and altogether deliver influences to the flood-prone areas (be it kampongs or real-estate housing neighborhoods); in order to portray the overlapping influences among diverse communities' responses to their neighborhoods and the influence of the changes in one neighborhood to the others.

The content of this paper is formulated based on the reflection of the initial result of short fieldwork research conducted in groups by student research teams of Water Urbanism Surakarta of the Department of Architecture Engineering, University of Atma Jaya Yogyakarta. To collect necessary information and data to develop validity of this paper, six research members jumped to the fieldwork locations in twenty-four days in between March 1st until May 31st of 2017, to gather primary data through necessary observation on the condition of built fabrics and infrastructures of several flood-prone neighborhoods in Joyontakan and Grogol. An interdisciplinary view, by borrowing techniques from qualitative social research was employed, which involves semi-structured interviews with local inhabitants, field observation, and documentation review of policies and plans. This qualitative method was employed to understand a rather complex social phenomenon, which cannot be identified only by visual observation. The semi-structured interview is a tool to clarify the ongoing information that has been gathered from visual information. This interview is also a tool to understand the logic and reasoning behind actions undertaken by flood-victims. Whereas, newspaper article reviews and literature studies on urban floods, especially relevant to the nature of Bengawan Solo's urban floods, has been used as secondary data to develop the analysis of this paper.

However, in collecting interviews and necessary data relevant to this research, several obstacles were also experienced, limited research time being the major constraint. The fieldwork was conducted within twenty-four days, in which the process was distributed in two-days of research per week. There was a discontinuity of observation in between weeks, resulting in a less intensive result of the interviews that had been initiated. Considering the overall research area contains parcels of very diverse characters of neighborhoods, the twenty-four days of fieldwork was still insufficient to gather as many information

as is the initial plan. Despite all of that, until the end of the fieldwork time, the team members were still awaiting permission to access significant technical information from local authorities. Therefore, the research teams were unable to verify several key technical information such as, the water debit and speed of the flood stream during flood events; due to data and information which have not been made public.

The self-modifications on built environments that have been taken by flood-victim inhabitants in reducing the risk and threat of flood have been documented by the researcher in several parcels of cognitive maps. These cognitive maps are being used as a tool to build spatial understanding, informing the location and the concentration of existing flood-prone neighborhoods and the locations where physical and infrastructural self-modification exist. These spatial maps are also employed as a tool to understand the pattern of dwelling fabrics that reflect the intensity of interaction among each dwelling house in a neighborhood. The aforementioned maps also help to inform the diverse characteristic among different neighborhoods and their physical relationship, which also aided the researchers to construct a visual understanding on the distance and physical interaction between a neighborhood and the adjacent rivers and streamlets, including the distance and proximity between the neighborhood and the entry of flood. The distance and the proximity among the neighborhoods, the rivers and streamlets and the entry of flood have an apparent influence on the form of physical and infrastructural self-modification of each neighborhood.

3. A theoretical reflection on urban flooding and urbanization, a fragmented settlements and the physical intervention responding to flood

3.1. Urban flooding and urbanization

A manifold of overlapping environmental problems that decrease the permeability of land and soils is the common trigger of urban floods. The risk of floods in urban areas tends to increase simultaneously following the expansion of urbanized lands into the peri-urban and rural areas.[1,2] However, the massive transformation of rural areas into urban areas is inevitable, especially in cities of developing countries such as Indonesia. With the expansion of physical developments in rural areas, massive conversion of rural lands brings direct consequences on the duration of puddle to evaporate, on the frequency of floods, on the amount of water that flow through the water channels and on the destructive capacity of floods.[3-11] However, the impact of the aforementioned hydrological disruption varies depending on the growth level of urbanization in each spatial.[12]

The hydrological disruption commonly triggers an increasing sedimentation along water channels and rivers and the decrease in capacity of lands to support water evaporation processes due to the reduced capability of lands to absorb water during the wet season.[8,13] With increased sedimentation, the water channels suffer from lack of spaces to contain the water flow. If the capacity of the lands to absorb water has also greatly decreased, the flood hazard is also simultaneously increased.[8,13] As massive urbanization drastically consumes the spaces for greenery, rainwater loses its medium to infiltrate the earth. As a result, rainwater has become an additional source of water-flood.[14]

When the urbanization process comes rapidly in spontaneous and sporadic patterns, the conversion of lands into built areas often comes beyond the anticipation of the existing urban planning. As a result, there lacks the presence of both urban sewage and drainage infrastructure networks that service the new expansion of settlements. The spatial areas that are located on flood-risk locations such as riverbanks are commonly inherent in the aforementioned quality.[15] Therefore, the risks of flood increase according to the occupation of land along riverbanks for residential and industrial areas. [16] Since these areas usually experience a decrease in economic value, these locations attract an expansion of low-income settlements which leads to uncontrolled expansions of disorganized covered land and chaotic settlements. [15] Therefore, Serrao-Neumann et. al., affirms that effective planning policies and

response can reduce the vulnerability of the disaster-victim communities to the impact of extreme weather such as the escalation of urban floods.[17]

However, the growth of urbanized land in developing countries such as Indonesia generally takes two different growth patterns; the planned urbanized land and the spontaneous and unplanned. [18] While the planned version normally covers the areas where urban planning and policies have access to regulate the settlements, the unplanned version usually takes place in areas that are occupied by squatters, slums, traditional communities and the unwanted communities. The unplanned growth of urbanized land can also take place on vacant spaces, such as at the border of two administrative regions or occupying vacant spaces along riverbanks. Hence the chaotic and uncontrolled sprawl of settlements. As for the planned urbanized areas, the pattern of its settlements normally follows a definite pattern such as the direction of rivers, roads or administrative boundary. [19]

3.2. Fragmented Settlements and Its Influence Effect to the Physical Self-Responsive to Flood

In the Indonesian urban context, kampung settlements tend to be associated with poverty, and backwardness. But the new settlements and real-estate housing clusters tend to be associated with progress, the wanted socio-economic classes, and modern societies. These two stigmas contribute to the production and construction of fragmented and segregated settlements due to differences in socio-economic classes. As a result, the aforementioned differences also reflect the socio-economical capacity of the major inhabitants of each settlement.

Differences in social and economic capabilities among the two classifications of settlements consequently build a barrier of social relationships. The predominant housing settlement of the higher socio-economic class tends to require more privacy. Hence, the tendency to limit access to other settlements and kampung neighborhoods. However, in term of economic capacity, they have better self-financial capacity to execute and construct any physical modification for flood-protection.

On the other hand, lower socio-economic class settlements tend to be more open in social relationships to other groups and settlement. As a result, community participation to handle the flood impact is more probable than the higher socio-economic class group. However, this socio-economic group has less economic capacity to conduct physical self-modifications to handle the flood due to financial limitations. As such, physical self-modifications in dwelling environments and housing units may be less in low-income settlements than higher-income settlements.

Moreover, in the course of urban flood disasters, the prevailing political regimes in Indonesian cities tend to place blame on low-income settlements at flood-prone areas as one of the main reason for urban floods along with the natural course of global climate change and increasing sea.[20] On the other hand, when land occupation involves a shift of ownership and uses correlated to business investments and large-scale land-development projects, floods are often framed as a ‘must be taken’ costs needed to be accepted in the name of ‘a better future development for the city’. [20]

3.3. On Physical Intervention as a Response to Urban Flood

Both national and local governments usually prepare several physical interventions to reduce flood events and their impact on urban and neighborhood scales. In urban scale, the most common physical modifications that have been implemented are the construction of river embankments in hard and non-porous materials, straightening the path of the river, re-planting forests and greenery along the river path and waterways, and constructing reservoirs. However, such modifications only serve as short-term prevention from floods.[21]

On the other hand, the latest studies on flood mitigation have shown that physical modifications by reshaping and changing the morphological form of a river increase the speed of the river flow, becoming stronger than its natural condition. This condition accelerates the process of soil erosion along the river path. As a result, the river flow will deliver the eroded soil to the estuary and the lowland. The process

of this erosion frequently takes place faster than the natural sedimentation and soil formation processes. [21]

Naturally, softscapes with natural soils along the river-base and riverbanks function as a medium that allows water to naturally permeate the earth. However, the construction of river embankments in hard materials restricts permeability. As a result, the river loses its ability to absorb water. In the event of an increased debit, the modified river subsequently transforms into a channel for flooding. Therefore, the construction of reservoirs helps to reduce the over-capacity of rivers, as it also functions as a container to catch the water flow from drainage channels. [22] To enhance the capacity of the reservoir in absorbing the overcapacity of flood waters, the construction of reservoirs is usually combined with softscapes, greenery, plantations, and parks.

Moreover, intervention at a neighborhood scale in Indonesia also frequently receives support from the local government. However, the local governments are usually only involved partially in supporting the physical intervention, while major actions have been handed over to the participation of the neighborhood communities. Due to the limited capacity of low-income neighborhoods, these communities usually gain priorities to receive support from the local authorities. The most common physical intervention that has been supported partially is the provision of water-gates to control water intrusion in flood-prone neighborhoods. The local government at occasion partially finances the provision of gates in selected neighborhoods based on priority. Nevertheless, this initiative is ironically and frequently handled without supervision from the government or from the experts. As a result, the water-gate often fails to secure the neighborhoods effectively and efficiently. Therefore, flood prevention actions are most frequently being executed by a self-mobilization action from the flood-victims local communities who create any alternative means of resilience to floods. [20] Such resilience initiatives are essential to raising the flood-victims' awareness on their right to the city. [20]

4. Describing and analyzing the physical self-modification of built environments in response to urban flood in the peri-urban settlements of Surakarta and Sukoharjo.

4.1. The Existing Condition of the Bengawan Solo River Flow and the Flood in Joyontakan and Grogol Areas

4.1.1. The Bengawan Solo River, Its streamlets and Flood Events. The Bengawan Solo River flows from the southern part of Java Island to the Northern part of the island. It functions as the main water channel for the provinces of Central Java and East Java. As it is recorded by the Balitek DAS Sungai Bengawan Solo, the massive conversion from open land to built-up areas occur upstream, to the areas of Wonogiri and Ngawi Regencies. This conversion plays a significant role in increasing the water level of the Bengawan Solo River when it passes the Soloraya Region. The expansion of flood on land continues to occur as it is worsened by the slow process to recede any puddle on the land. This condition is due to the massive changes of many flood-free areas following the expansion of settlements and built areas along the Bengawan Solo River, especially in Sukoharjo and Wonogiri Regency; which apparently causes the decrease in capacity of the soil to absorb water at urbanized lands and along the riverine. These regencies initially acted as water catchments and agricultural areas for Soloraya Region.

Moreover, the decreased capacity of water catchments along the Bengawan Solo River has also been triggered by the gradual deprivation of green spaces along the riverbanks. At least twelve-meter-wide green open space should be reserved on the riverbanks of the Bengawan and its streamlets; in an effort to provide spaces for natural water absorption, maintaining the natural water flow of the river in both normal and flood conditions, and maintaining an adequate amount of spaces needed for natural floodplains as well as maintaining the direct connection between the water body of the river and the floodplains when flooding occurred.

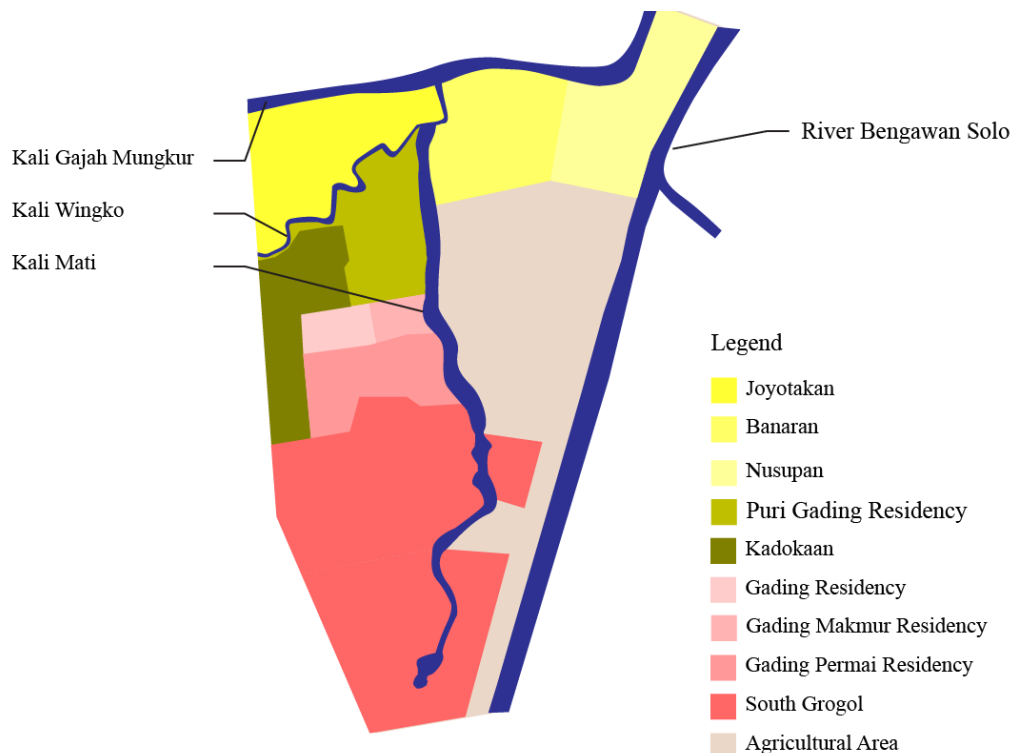


Figure 1. Research fieldwork area.

The recent development of mainstream research on urban flood has concluded that allowing natural water absorption by increasing the amount of green space along the riverbanks is considered as the most effective and sustainable way to reduce the impact of floods to settlements. This way is considered more effective than constructing hard-engineering solutions, such as concrete embankments. If this ideal condition can be achieved, direct flooding impact to settlements can be avoided. However, in practice, the construction of levee and expropriation of space along riverbanks for extended dwellings remain dominant on the riverbanks of the Bengawan and its streamlets for many years. As a result, these hard structures cover the absorption surfaces of the riverbanks, interrupts the direct river connection with its necessary floodplains during a flood event and consequently reduces natural spaces necessary to hold the overcapacity of water flow. Although the latest environmental campaigns promote the revitalization of riverbanks as green open space floodplains as the most recommended solution to tackle the increased urban flooding; however, this solution is still difficult to realize by many cities in developing countries due to high financial and social costs. Its realization in cities in the developing world has been challenged by inevitable massive settlements needed to be relocated to give spaces for the programs, which brings consequences on high expenses needed to be prepared by the local government. As a result, a hard engineering solution such as the construction of additional levees to protect settlements from water still become the favorable solution.

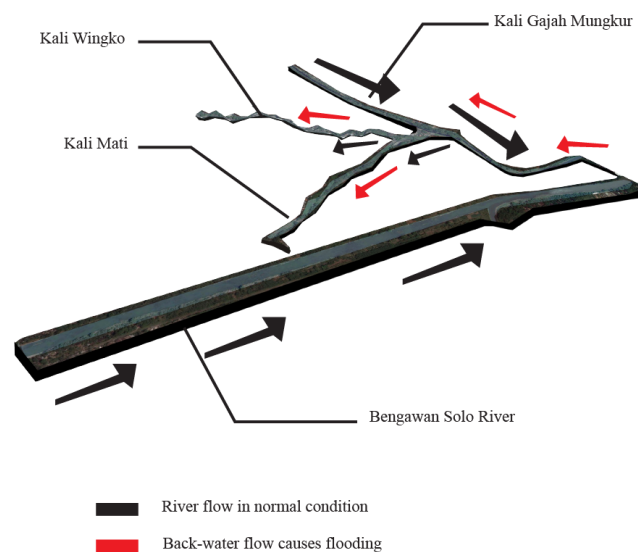


Figure 2. An extra water-flood caused by back-water flow.

Moreover, the water flow of Bengawan Solo River and its streamlets also tends to increase following the increased intensity of rainwater. As a result, the maximum water level of the Bengawan Solo River and its streamlets shows an increasing trend every year during the wet season. The possibility that the water from streamlets being unable to enter the Bengawan Solo River is evident since the main Bengawan River has reached its maximum water-level capacity. This condition triggers an additional flood threat to settlements nearby the rivers due to a potential back-water flow from the Bengawan Solo to its streamlets and then entering the smaller water channels in settlements. An extra water-flood caused by back-water is inevitable. The role of the back-water in urban floods of the Bengawan Solo has delivered an equally significant impact to neighborhoods as the true flood-water from the river.

4.1.2. The Precondition of the Flood-risky Settlements of Joyontakan and Grogol. The location of Joyontakan and Grogol is within lowland areas to its surrounding neighbors. Towards the north, the ground level is lower than the southern areas. These areas are surrounded by two streamlets of the Bengawan Solo River; Kali Gajah Mungkur and Kali Wingko. These areas are also adjacent to the former Bengawan Solo water channel, also known as Kali Mati, which is located behind the two sub-districts. Moreover, the recent channel of the Bengawan Solo River is located within a 500-meters distance from the observed area. This geographical location consequently positions Joyontakan and Grogol within critical risk conditions from the rivers. Nevertheless, almost every inch of land in and around those three streamlets have been occupied by dense [and mostly legal] settlements for many years. Therefore, any scenarios to give spaces for greenery are difficult and almost unrealistic to be executed.

The three streamlets contribute to flash-floods to the area in two different ways, which are complementing to each other in escalating the scale of the floods. Kali Gajah Mungkur and Kali Wingko are the streamlets of the Bengawan Solo River that actively function to channel the water flow from Klaten Regency to the Bengawan Solo River. Unlike the two streamlets, Kali Mati no longer acts as a water channel in normal days. In Indonesian term, Kali Mati means a dead river or a former riverway that is no longer functioning.

Kali Mati is located nearby the confluence of Kali Wingko and Bengawan Solo River. Its location is near the entry location of Kali Wingko to Bengawan Solo River. Kali Mati and Kali Wingko are smaller in dimension than Bengawan Solo. The riverbanks of both streamlets are occupied by dense settlements, both kampong settlements and real-estate settlements (including Joyontakan Kampung and Puri Gading

Housing), and [un-]official urban dumpsters. Most settlements along the two streamlets are located below the water level of the streamlets during maximum capacity. Thus, limiting space along the waterways available to accommodate the overflow of water when the streamlets are at maximum capacity.

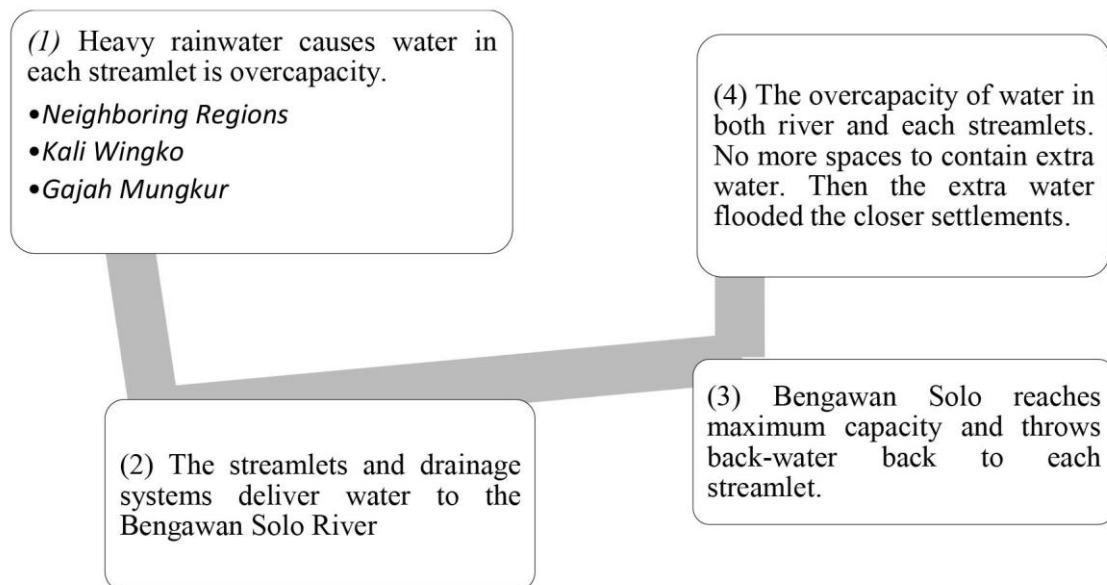


Figure 3. A diagram showing the flow of back-water reaches the settlements.

When rainwater comes in high capacity and in long hours in Soloraya Region to its neighboring regions, Kali Wingko, Kali Gajah Mungkur and other streamlets of the Bengawan Solo are at maximum capacity. The streamlets will try to deliver water entering all inlets to the Bengawan Solo River. As soon as the Bengawan Solo River reaches maximum capacity, water from the streamlets can no longer enter Bengawan Solo. The water-flow from Bengawan Solo River, which is stronger than the water-flow of the streamlets, will force the water back to the streamlets. In the case of settlements along Kali Wingko, the overcapacity of the river cannot find extra spaces to accommodate the water or to redirect the water to spread to other directions.

Therefore, when rainwater comes in high capacity and in long hours, the overflow from Kali Wingko and rainwater fills the residual space of Kali Mati and transform the space into a dead-end pond. When the debit of water in Kali Wingko, the Bengawan Solo, and Kali Mati have reached maximum capacity, this temporary dead-end pond of Kali Mati turns into a source of floods to the surrounding settlements. Therefore, Joyontakan and Puri Gading areas experience longer pools during the rainy season and frequently suffers more flood-impact damage. While the two aforementioned settlements suffer by floods from Kali Wingko, Kali Mati, and Bengawan, the Nusupan Kampong is more affected by flood from Bengawan Solo River and Gajah Mungkur River, even though the northern areas of Nusupan are also impacted by the dead-pond of Kali Mati. Nusupan and the southern areas of Grogol are less affected by floods compared to the northern settlements of Grogol. However, the lack of proper drainage in this area has delivered equal complexity on the problem of seasonal floods.

4.2. Common Physical Responses to Deal with Flood and the Influence of Fragmented Settlements

The settlements of Joyontakan and Grogol are the result of uncontrolled urbanization of Surakarta city, formed from a collage of diverse parcels of neighborhoods, in which each parcel has diverse socio-economic backgrounds. Several neighborhoods were formed spontaneously and organically in the form

of peri-urban [traditional] kampong, while others were intentionally built by local developers in the form of real-estate housing neighborhoods. Each neighborhood has its own socio-economic and resilience capacities to deal with the impact of floods.

The diverse socio-economic precondition of each settlement in Joyontakan and Grogol has also brought different treatments from the local government in delivering aid and support to in terms of flood response. The kampong neighborhoods consist of Joyontakan, Nusupan, and Kadokan have been targeted as priority neighborhoods to receive government support and flood-reduction programs. On the other hand, the real-estate neighborhoods of Puri Gading, Gading Permai, Gading Makmur, and Gading Regency, although they are also impacted by floods, have been unsubsidized by the government's flood-reduction program and have been left to handle the floods by themselves.

However, to both communities, being flood-victims for years have brought a life-learning experience on how to deal with flood depending on their individual capacities. Therefore, with or without the presence of official flood-reduction programs from the local government, these communities have actively developed knowledge and actions to manage flood, either through physical infrastructural modifications or through socially oriented actions and approaches.

Table 4.2 Socio-economic precondition brought different treatments from the local government in delivering aid and support to in terms of flood response.

No	Study Area	Type of Settlements	Level of flood distruction	High to middle Priority	Low Priority
1	Joyotakan	Kampong	+++++	✓	
2	Banaran	Kampong	+++	✓	
3	Nusupan	Kampong	+++++		✓
4	Purigading Residency	Housing	+++++		✓
5	Kadokaan	Kampong	+++	✓	
6	Gading Residency	Housing	+++++		✓
7	Gading Makmur Residency		+++		✓
8	South Grogol	Kampong	++	✓	

4.2.1. The Diverse Characteristic of Neighborhoods and Its Impact to the Physical Response of the Inhabitants in Creating a Flood-Protection for the Neighborhoods Environments. The account below describes and analyses the physical self-modifications and actions on the dwelling environments that have been implemented by the inhabitants of Joyontakan and Grogol in their attempt to reduce the impact of floods in their neighborhoods. The diverse condition of the site is grouped into three groups of settlements following the dominant characteristic of each settlement. They are the Joyontakan, Puri Gading, and the Nusupan settlements.

Joyontakan Kampong Settlement

Joyontakan consists of several kampong neighborhoods that grew gradually and mainly organic for decades; some others were formed by [former] squatters and are considered as poor neighborhoods. This condition has positioned the area as a target priority for flood-reduction programs from the government.

Due to the irregular, unplanned, and chaotic formation of this settlement, the drainage systems and network of the settlement are also chaotic and disconnected into several fragments. As a result, the settlement suffers from a very poor and ineffective drainage system. Hence Joyontakan has always been the most vulnerable to floods before 2010 when the Surakarta Government delivered a flood-reduction program by reconstructing the drainage system.

The flood threat in Joyontakan is accelerated by the fact that the location of this settlement is at the lowest land of its surrounding region, acting as a basin for the surrounding sub-districts. Joyontakan's critical position to flood-threat is also accelerated by the fact that this settlement is also flanked by Kali Gajah Mungkur and Kali Wingko at its northern and southern parts, as a consequence of this condition, Joyontakan acts as natural rainwater collector for the immediate region. However, the major land of this basin has already been covered by dense settlement for years, blocking the process of natural hydrological absorption of rain and river water.

Three major flood-reduction projects have been executed by the Surakarta local government in 2010 to secure the settlement from floods. The river embankment, constructed with a hard-engineering approach along the riverbank of Kali Gajah Mungkur in an attempt to secure the flood-plain from the direct intrusion of settlements' expansion and its dwellers. The drainage system of the neighborhoods was also reconstructed; and lastly, funding to purchase, build and install neighborhood water gates and water pumps was also delivered to the kampung communities of Joyontakan, all in an attempt to control the intrusion of flood-water entering the neighborhoods during flood events.

However, there was an absence of proper supervision from the government regarding the installation process of the water gates and pumps; affecting the positioning of the water gates and the pumps to be less effective in controlling the water flow in the settlements, deeming the existing water gates and pumps insufficient to secure the settlement from flood. Moreover, due to the absence of communication and coordination between the neighborhoods of Joyontakan and Puri Gading regarding the selection of locations for water gates and pumps, the overcapacity of water that was discharged to Kali Wingko has frequently contributed as an extra source of flood to other settlements, especially to Puri Gading, which is located adjacent to Joyontakan and directly borders Kali Wingko.

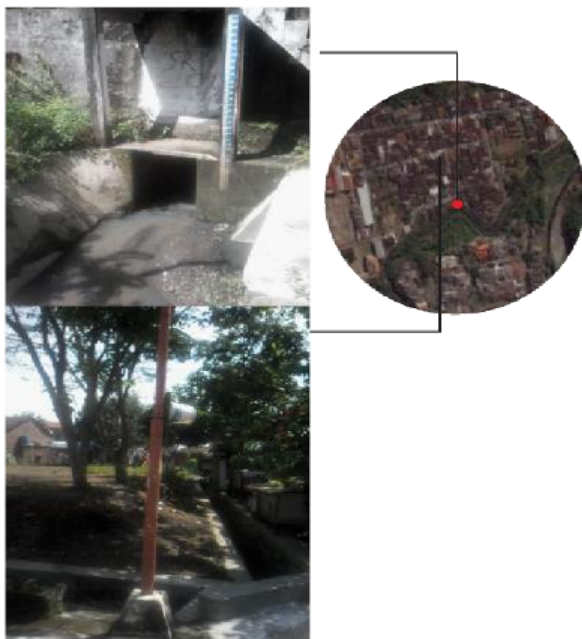


Figure 4. Direct flooding flow from physical responses to the drainage system.



Figure 5. Watergate in Joyontakan and the event when waterflood began entering the neighborhood.

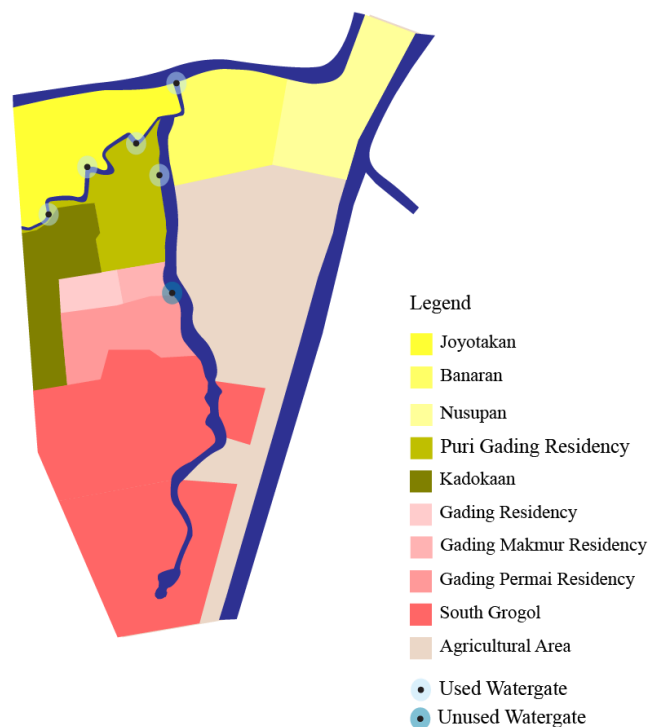


Figure 6. Distribution of used and unused water gates in Grogol.

Moreover, due to the installation of water gates and pumps in Joyontakan, the extra flood-waters intruding the settlement has been disposed directly to Kali Wingko. In flood-critical conditions, this water discharge ironically contributes to additional water capacity of the streamlet, as a result, it has also contributed in accelerating floods and increases the potential development of the flood in becoming a more catastrophic flash flood, especially during heavy rains.

Puri Gading [real-estate] Housing Settlement

Puri Gading has different characteristics from Joyontakan, experiencing a more direct flood threat due to its location that is surrounded by Kali Wingko and Kali Mati. However, this housing neighborhood has not been targeted for priority support of Government flood-reduction program. Therefore, the neighborhoods within Puri Gading have to resort to private initiatives and financial support. Among several real-estate neighborhoods in Grogol, only Puri Gading has actively tried to find a solution to reduce flood-water infiltration into their neighborhoods and protection from flood damage.

Since the flood threat has increased in frequency within the last ten years, the residents of this neighborhood have decided to protect their settlement by constructing flood-protection retaining wall along the boundary of the settlement and the rivers by themselves through financing the construction by community participation. However, since the riverbanks lose space for water infiltration due to the retaining walls, the water capacity of Kali Wingko and Kali Mati increases during the flood. The water surface of the streamlets increases over the normal capacity of the streamlet, extending the duration of the water to return to its normal state. Since both water from the streamlets and runoff from Puri Gading try to find a way to flow to the immediate rivers, the water pressure in the soil of the neighborhood increases drastically, as it tries to create new capillary waterways to the river. The increasing pressures from both groundwater and the streamlets have gradually created extra force and pressure on the

immediate substructures of the buildings, the flood protection retaining wall and the soil of the existing of the neighborhood. Findings during field observation have identified a steady increase of deterioration to substructures of houses and soil landslide in the neighborhood, most commonly to houses that are located adjacent to Kali Wingko and Kali Mati, indicating an apparent new threat from the side effects of the aforementioned environmental modification in this settlement.



Figure 7. Landslide in Puri Gading.

Apart from constructing retaining walls, the residents of Puri Gading have also tried to protect their neighborhoods by installing numerous water pumps and water gates in an attempt to dispose of and to reduce flood water intrusion from streamlets entering the drainages of the neighborhood. The intrusion of flood water in Puri Gading has been disposed to Kali Mati and Kali Wingko, the flood water in both streamlets remains in overcapacity and keeps delivering pressure to enter the neighborhood.

Nusupan Kampong Settlement

Unlike Joyontakan and Puri Gading, the environmental modification for reducing the impact of floods is still absent in Nusupan, even though the settlement has also suffered from flood. Nusupan settlement is located immediately to the retaining embankment of the Bengawan Solo River. The Bengawan is located along the southern and the eastern boundaries of Nusupan. The settlement is located below the normal level of the river, hence, when the Bengawan has reached its maximum water capacity, water will intrude the neighborhood through the existing water gates and drainage. Moreover, the northern part of Nusupan also receives flood threat from the end part of Kali Mati. Therefore, both the water intrusion from the Bengawan and the Kali Mati are the main causes of flooding.

Nusupan is the newest settlement in Grogol area, recently growing in the past ten years due to the concentration of many industrial buildings in this area. The existing drainages have a lack of depth even only to flow normal water capacity. During fieldwork, fragments of disconnected drainages were found throughout the kampong. In several alleys, the drainage abruptly ends without connection to the urban drainage network. Moreover, since its location is on the immediate lowland of a major river, the already

insufficient drainage system is further complicated due to clogging from mud and soil from the intrusion of river water.

Interviews that were taken from the site revealed that the northern settlements are more aware of the danger of floods. Therefore, the self-initiative of the communities to develop protection from floods are also stronger. However, the southern settlements' inhabitants such as Nusupan have a lesser sense of urgency to modify their settlements in order to create a more protected neighborhood. The decrease in urgency is manifested through their acknowledgment of what conditions are considered as being hit by floods. The psychological adaptation of each community in these flood-victim settlements plays a significant impact on the way they acknowledge a flood event. When floods are below 50cm, it is yet to be considered as a flood. They will consider the event as a flood event when the water has entered their houses once it reaches at least 30cm above the ground floor or once their houses are full of water. Therefore, the physical self-modification to secure the dwellings from floods in Nusupan generally only exists inside individual housing units.



Figure 8. Flood in Nusupan

Furthermore, the interviews in Nusupan also revealed that for the residents of Nusupan, the source of floods on their settlement does not come from the location of their settlement that is immediate to the Bengawan Solo; or due to the lacking conditions of the drainage system. According to their understanding on the condition of their settlement, the source of floods that hit their settlements have been triggered by the construction of embankments along Kali Gajah Mungkur in Joyontakan and also due to the installation of the main water gate at the intersection of Joyontakan and Kali Mati. Prior to the construction of those physical interventions, their settlement was free of floods. Their opinion shows an apparent indication that the physical intervention at the other neighborhoods may lead to a negative side effect to their neighboring settlements. Therefore, a proper comprehensive planning and study covering larger extending environments need to be completed before the next physical infrastructural modification is executed.

4.2.2. The Diverse Socio-Economic Characteristic of Neighborhoods and Its Impact to the Physical Response of the Inhabitants in Creating a Self-Modification of Housing Units to Reduce the Impact of

Flood. The diverse financial capacity of each household and neighborhood has delivered various capacities to execute physical self-modification on neighborhoods and houses. It also influences the social relationship characteristic of each neighborhood and the way this social relationship brings influence to community flood response.

The most common dwelling modification implemented is to raise the ground floor. Differences in financial capacity contribute to the scale of modification undertaken. Middle to lower-income households tend to elevate the ground floor level at least from 50 to 100 cm above street level, while upper-middle to high-income households elevate their ground floor level up to and above 300 cm above street level. Despite all of that, many households have also decided to renovate their houses into two-story houses. Additionally, the proximity of each house to the inlet spot of water from the nearby river also brings influence on the level of height of the ground floor.

Moreover, the residents of flood-victim housing clusters in real-estates housing in Grogol tend to request more privacy for their dwelling units and neighborhoods than the residents of immediate kampongs. Therefore, an increasing number of houses are protected by individual fencing. With the increasing threat of flood in this area, more fences have been rebuilt to become waterproofed fencing barriers. These fences also function to prevent flood-water from the street entering the plot. Again, in this regard, diverse financial capacities of each household influence both the quality and quantity of the modifications that have been undertaken. The wealthier a family household, the higher the level of the ground floor and protective fencing built. As of today, these two self-modifications are predominantly found in real-estate housing neighborhoods, especially in Puri Gading. However, similar modifications are also found in other housing clusters and at the nearby kampongs, depending on household financial capacity.

The aforementioned physical modifications are merely taken in an attempt to block the floodwater entering houses. By increasing the height of the ground floor and by constructing waterproofed fences, the neighborhoods still experience a decrease in the amount of natural ground with open soil surfaces. As a result, the space for water absorption and infiltration has steadily decreased. During heavy rains and during flood events, puddles on the ground and floodwater become more difficult to infiltrate the soil; which leads to the increased duration of floods.

Unlike the modifications that have been taken by many houses in real-estate housing, the majority of kampong houses in southern Grogol applies a different modification approach. Only few houses elevate their ground floor or renovate their houses to become two-story houses. But more and more households have decided to use the space of their attics as a *ranggon*; an emergency space to store their belongings. Those who do not have an attic in their house use tables as a space of emergency to avoid the flood water in damaging their belongings. The two latest approach is commonly being applied by households with lower economic capacity.

5. Conclusion

Learning from the case of Joyontakan and Grogol, any response and action to deal with flood impact need more than an individual and group's awareness and actions. Massive and uncontrolled urbanization, play a significant role in adding the threat of flood. Their existence continues to decrease the amount of land and soil that are available to absorb water. Therefore, handling the threat of flood cannot only be solved by hard-engineering solution or individual physical responses.

Table 5. Summary.

	JOYONTAKAN	PURI GADING	NUSUPAN
Urban fabric formation	Dense Irregular kampong	Less dense Regular housing	Less dense New settlements mix of regular and irregular neighborhoods
Socio economic level	Low to middle income	Lower middle to upper middle income	Low income
Location	Below normal water level	Above normal water level	Below normal water level
Support from government	Early warning system Water gates and pumps Construction of river embankment Water channel improvement	Early warning system	Early warning system Water gates and pumps Water channel improvement
Self - actions	Water gates and pumps installation Individual house modification Maintaining water channels	Water gates and pumps provision and installation Individual house modification Construction of fences Construction of perimeter wall	Maintaining water channels
Awareness to the threat of flood	++++	++++++	++

There is a need for comprehensive solutions that consider future hydrological cycles of regional-scale rivers. The solution must also cover the influence and impact of the implemented actions to neighboring settlements and regions. In the case of Joyontakan and Grogol area, the solution cannot be merely provided parcel by parcel, because one solution that was applied to one particular settlement may trigger extra flood-threats on other settlements. As is the case for Joyontakan and Grogol, a scenario to provide extra open land and green spaces to increase land capacity to absorb water needs to be prepared by comprehensive urban planning. Moreover, the engineering solution to the existing urban flood also needs additional physical infrastructural solutions on the mezzo level. If constructing river embankments remains the macro, there is a need to provide a mezzo-scale solution to secure the district scale level from floods. For Joyontakan and Grogol, preparing water catchment reservoirs may help to secure the existing settlements from overloading backwater from the Bengawan Solo and the streamlets.

Moreover, preparing communities to be aware of the cause and the actions to reduce flood threat is undoubtedly useful to secure the inhabitants from damage at micro-level. However, proper coordination between different neighborhoods and supervision from experts and governments remains critical in order to reduce the negative impact of individual actions on the other neighborhoods. Therefore, flood mitigation planning and guidelines that cover from macro to micro level needs to be prepared properly.

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