Research Paper

Kampung dwellers' resilience and adaptive responses to climate change hazard

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Abstract

Some kampung dwellers live in poorly built houses on disaster-prone areas, such as the riverbanks. Although floods come quite regularly when heavy rain falls, it may not be wise to have them relocated since such an option may result in collapsing their livelihoods. Adaptation is sought as an alternative solution towards disasters, rather than merely relocation without careful consideration. This paper tries to explore the extent of flood hazard, vulnerability, and adaptation made by kampung dwellers in the cities of Solo and Cimahi in Indonesia. Data collected from observation and interviews are descriptively analyzed and shown as indexes resulting from a modified UNDRR Disaster Resilience Scorecard for Cities. It was found that these two kampung have flood hazards with different intensity and hence destructive characteristics. Nonetheless, most kampung dwellers have got accustomed to floods and made adaptations to lessen the risk of loss. Elevated floors, simple flood gates, and ceramic tiled walls have become retrofitting methods for the kampung dwellers. Results deriving from the tool have shown that it provides a useful site-specific baseline but needs to be followed by further scenarios such as identification and prioritization of plans and acts.

Keywords

Kampung, flood, adaptation, resilience

1. Introduction

According to CRED-UNISDR report (2018), 80 – 90% of natural disasters within the past ten years are related to climate change, i.e. drought, storm, and flood. Flood, for example, has impacted two billion people within the years 1998 – 2017 worldwide. In Indonesia, there were 5252 events of flood within an 8 years period from 2012 to 2019 which resulted in 5100 victims, 98768 damaged houses, and not to mention damaged schools, health facilities, bridges and roads. Because of the flood, health has been directly and indirectly affected in many ways, including drowning and other physical trauma; water-borne infectious diseases; disrupted health systems, facilities and service; and damaged basic infrastructure such as food and water supplies and safe shelter.

The Sendai Framework for Disaster Risk Reduction 2015-2030 has set the global plan to reduce disaster losses by reducing existing levels of risk, avoiding the creation of new risk and managing risks that cannot be eliminated. Such plans are often translated into actions which lead to enforcement of land use regulations, implementation of building codes, and preservation of protective eco-systems. Nonetheless, in high-density built-up areas such as kampung, such actions are difficult if somewhat impossible to be carried out. Physical, spatial, and economic limitations made specific conditions in which only limited disaster mitigation options are feasible.

Kampung dwellers, in which most of them are poor, are one of the vulnerable groups in Indonesia. Poorly built houses and located within disaster prone areas, such as the riverbanks, are two of many reasons for such vulnerability. Originally, some kampung incrementally developed on riverbanks to be near a water resource. Throughout the year, these kampung are most likely to be flooded when heavy rain falls. Lack of permeable spaces and drainage to handle stormwater treatment in the city caused it to flow through kampung alleys finding ways to rivers since it has lower topography. There are reasons behind the poorly built houses: not only their limited affordability but also lack of land tenure since there is a risk of demolition (Wamsler, 2004). On the other hand, it may not be wise to have the kampung dwellers relocated in order to reduce their vulnerability since such an option may result in collapsing their livelihoods (Blaikie et al, 1994). It is thus important to address adaptation as an alternative solution towards disasters, rather than merely relocation without careful consideration.

Adaptation can be considered as mitigation since it reduces the risk of disaster by increasing the ability to respond to hazards. An effective mitigation planning therefore needs vulnerability assessment which includes collecting data on population, property loss, economic and resources limitation to recover from disasters, including society attitudes, preparedness, and awareness of disasters. There are wide varieties of tools available for disaster risk reduction planning but the majority are very specific and highly complex in technicality that it requires an expert to assess hazard as well as vulnerability within a location. However, UNDRR Disaster Resilience Scorecard for Cities, for example, is useful and quite easy to understand but limited in terms of how practical it can be utilized by communities to increase their capacity, adaptation, and mitigation to disaster events. It is the intention of this paper to bring glocal solution to reduce the vulnerability of kampung, by modifying the scorecard as one of the means.

2. Understanding the context of kampung and disaster

2.1. Vulnerability of kampung dwellers

Urban growth, either formally or informally, rarely coincided with disaster risk reduction efforts (Wamsler, 2004). Planning regulations, such as zoning and building code, tend to bring no effects on the socially vulnerable people living in high density urban areas (Velasquez et al, 1999). In other words, such planning regulations are considered useless or irrelevant for the poor and informal society. One of the reasons is because in such areas, in developing countries particularly, construction is an informal sector activity (Sida, 2002).

Wamsler (2004) argues that there are two groups of disaster studies. While one group tends to focus on predicting hazards and its technical solutions, the other group is more socially oriented, focusing on poverty and social factors of disaster vulnerability. From this second group, it was found that there are many factors affecting society's priority which result in low investment on building safety. On disaster high risk locations, modern style houses are built, for a mere for social status, rather than proper structure. Land tenure may also become a factor. People will not invest on building safety features on their houses if they are feared of getting demolished—as a possible consequence of living on squatters. They will rather build houses with simple, cheap, or scavenged building materials (Wamsler, 2004). Other findings on social studies show that relocation as an effort to reduce vulnerability tends to bring an end to their livelihoods (Blaikie et al, 1994).

Kampung can be the most vulnerable location in urban areas to flood, drought, fire, earthquake as well as other hazards. Low environmental quality, substandard buildings and infrastructure, and high building density, in addition to flood-prone location, are the typical characteristics of Indonesian urban kampung.

In the case of fire, houses in kampung are easily burned due to highly combustible building materials, no spaces between houses, narrow alleys inadequate for fire engines, and low access to water hydrants or fire extinguishers. During an earthquake, houses in kampung may collapse to one another—known as the domino effect. Due to the high population and building density, it is a big challenge to plan an evacuation route. Determining which narrow alleys within a route, avoiding congestion and stampede, and targeting which building with sufficient capacity for evacuation shelter are difficult to do due to limited land and space.

Kampung tends to experience floods during the rainy season and drought during the dry season. Climate change amplified such disasters, including extreme weather. In the dry season, dwellers may not have access to clean water since most of them rely on water wells. In some typical cases, kampung is located adjacent to industrial plants whereas water is sourced from artesian wells. As a result, according to data from the Coordinating Ministry of Maritime, land subsidence has been found in more than 130 cities/regions throughout Indonesia. Andreas, Abidin, Sarsito & Pradipta (2019) have provided the following map on their prediction that at least 15 urban areas will experience land subsidence.

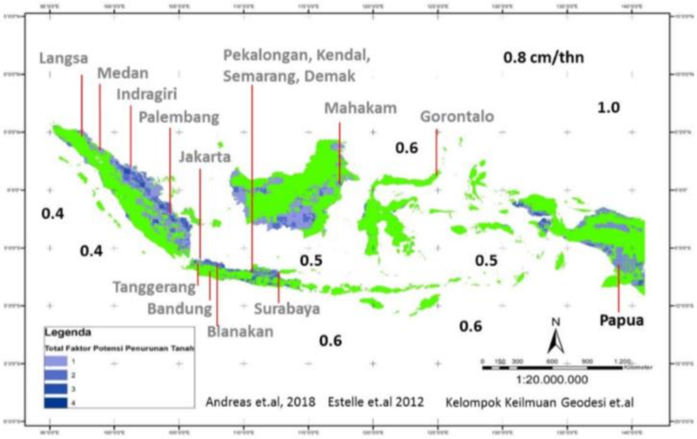

Figure 1 Cities with land subsidence in Indonesia
Source: Andreas et al. (2019)

Land subsidence in Cimahi and Bandung city, for example, possibly began to happen along with land cover changes in 1980-1990 with only a few spots in the southern parts. It was then expanded to the northern and eastern parts in 2000. In 2010, land subsidence was found nearly throughout the two cities, with 2 meters subsidence in the center. Later on, in 2016, land subsidence reached up to 3 meters and kept on expanding (Andreas et al., 2019). Andreas et al. (2019) further argue that around 1975 that initial year anthropogenic land subsidence in the Bandung area took place. Such prediction was made based on data extrapolation of land subsidence data and water table decline (e.g. one meter land subsidence is roughly correlated with 20 meters water table decline). Beside climate change, it is worthy to mention that land subsidence has also escalated the flood problems by creating basins which collect water runoff.

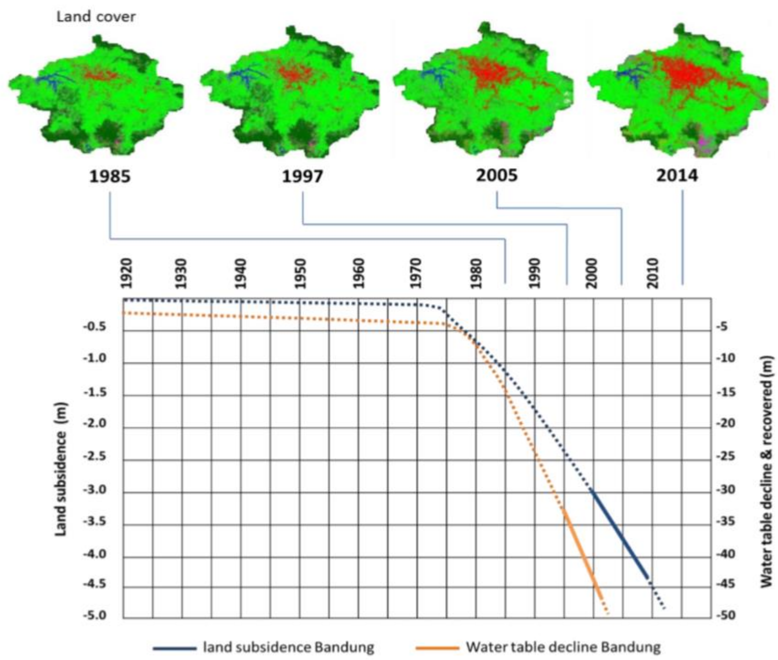

Figure 2 Land subsidence and water table decline in Bandung
Source: Andreas et al. (2019)

With such vulnerability, kampung dwellers tend to experience property loss in an event of disaster. In major disaster events, victims may leave their collapsed houses and find refuge in emergency shelters. After hazards have passed, they may be relocated to temporary shelter, then to temporary housing before finally residing in permanent housing (Lindell & Prater 2003). Throughout these processes, however, victims are heavily dependent on assistance since they no longer have a source of livelihoods. Facing uncertainties and weighing the risks, it is understandable that many people choose to stay in their houses unless being forced to evacuate or relocate.

2.2. Disaster mitigation planning and resilience

Disaster mitigation is an effort to reduce hazards, reduce vulnerability, and increase capacity in order to reduce disaster risk. Risk reduction lies at a different discipline to resilience, according to Pelling (2003). Risk reduction basically lies at a more practical level, while resilience lies at a more conceptual level. Studies on adaptation to disaster and hazard tend to calculate the potential of shocks and stresses to be encountered by the future cities, including water scarcity, food price increase, and warming global temperature (Newman, Beatley & Boyer, 2017). Meanwhile, resilience has been defined in many ways even though basically it relates to essential ability to adapt and respond to shocks appropriately. Composed of a social network community and lifeline system, resilient cities will grow stronger by adapting and learning from disaster (Newman & Beatley, 2013).

Resilience has been said to originate from ecological science, it was firstly defined by Holling as "a measure of system stability and its ability to absorb change and disturbance while keeping the same relations among populations or previous variables' '(Holling, 1978: 14). Resilience has been understood as a capacity of a system to absorb shocks and retain its balance or previous function (Gunderson, 2010; Mehmood, 2015; Sharifi & Yamagata, 2016; Holling, 1978; Folke, 2006). Expanding the previous definiton, resilience refers to system capacity in making adaptation and transformation, rather than merely recover from shocks (Caputo, Caserio, Coles, Jankovic & Gaterell, 2014; Elmqvist (2014).

3. Methodology

This paper tries to explore the extent of flood hazard, vulnerability, and adaptation made by kampung dwellers in the cities of Solo and Cimahi. Further, it also tries to analyze their resilience to flood. Data was collected from observation and interviews. Data from observation are descriptively analyzed. Interview transcript went through content analysis. The result was then used as inputs to fill out a modified assessment tool from UNDRR Disaster Resilience Scorecard for Cities which then resulted in indexes.

DisasterResilience Scorecard for Cities was developed based on Ten Essentials for MakingCities Resilient. Ratherdifferent from the viewpoint of the UNDRR Quick Risk Estimation Tool, this scorecard offers a series ofassessments which allows local governments to assess their resilience to disasterby involving stakeholders to enrich the assessment and gain a thorough view. The result of this scorecard can be useful to provide a basis for a detailed city resilience action plan since itcovers 117 indicators. Nevertheless, for the purpose of this study, a modification on the scorecard was done by simplification to focus only on the physical and social measurement that would easily identify ways to reduce flood disaster risk by the residents themselves.

The modified scorecard was utilized to calculate interviews and observations data into an index on flood and radar charts that consisted of four groups: hazard, vulnerability, capacity, and mitigation-adaptation. The input data for hazard were frequency in a year, flood level in cm, drain time in hours, cause of flood, total area of flood in hectares or amount of houses, and damage. For vulnerability, data were location nearby river with or no embankment, percentage of green open space, contour slope, and damage. The input data for capacity were an early warning system, open space for evacuation, evacuation route and signage, awareness on when to evacuate, and awareness on how to evacuate. The input data for mitigation and adaptation were structural mitigation on flood management, mitigation by residents, and adaptation in terms of house modification.

4. Results and Discussions

4.1. Flood hazards in Mojo and Cigugur Tengah

The two kampung of Mojo and Cigugur Tengah, based on official national data of Inarisk as well as interviews on residents, are prone to flooding. However, the flood has different intensity and hence destructive characteristics. It is presumed that floods are partly caused by the topography of both kampung and lack of drainage capacity.

In **Mojo**, inarisk data have shown that it has a high flood hazard. Interview results with the kampung dwellers of Mojo have also indicated a similar pattern: floods regularly happen. Mojo had once experienced a huge flood which brought material destruction, however, no fatalities were found as casualties. Based on the house location of respondents, it can be aggregated that flood is differentiated according to location. Floods with half door height occurred in the lowest level area on the east, flood then occurred at knee-height or medium level gradually found towards the west. The characters of flood in Mojo are shown in the following quotes:

"Flood, it went into the house in 2007.. everytime when heavy rain falls, if the drainage has not been cleaned, (our) house must be flooded." (MYT)

"Knee-high for sure..every time when heavy rain falls there must be flood." (WGT)

"The residents have gotten used to it. When heavy rain falls, we do not get to sleep. We can see that water level has risen, when there is a high water level in the sewer it means that the river has overflown." (SYN)

"(When a flood happens), houses that are made of *gedheg* (bamboo woven) are broken. "(PD)

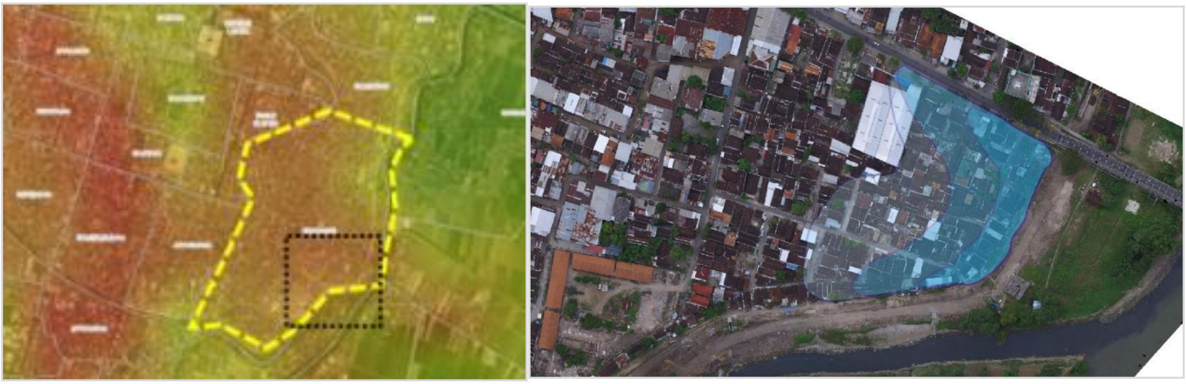

Figure 3 **Flood hazard** maps of Mojo
(left: official national data, right: according to interviews)
Source: Inarisk; MoPWH. (2019)

Figure 4 **Flood hazard** map according to interviews
Source: MoPWH. (2019)

In **Cigugur Tengah** case, the flood hazard has been said to be low destructive. According to the Local Disaster Management Agency, flood is not considered to have high risk because while it may be varied in water level, flood tends to dry off quickly. With such low risk, not much preparations or mitigation efforts are in place as quoted below:

"In this city, the highest risk of flood is found in Melong area. It is pretty high, residents usually evacuate to the second floor, but it (flood) dries quickly. In a matter of hours. We therefore do notprepare contingency plan for flood." (BPBD)

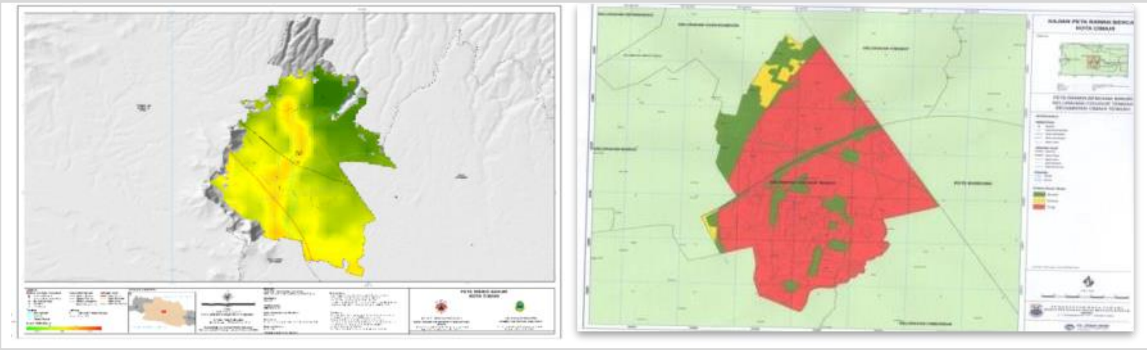

Figure 5 **Flood hazard** maps of Cimahi city and Cigugur Tengah sub-district
Source: BPBD Cimahi

Data from observations and interviews, however, shows a rather contradictory result. Upper photos in figure 6 show that the river channel is meandering and has 2 meters width at the upriver, widened to 4 meters width then narrowed down to 2 meters at the downriver. The river also has a confluence, shown at the middle photo, where floodplains are usually found. Meanwhile, the bottom photos show the flood conditions when the river overflows with high velocity. The resulting flood event caused the fence, located at the meandering part near the confluence, to collapse. The flood stream flows into the Mahar Martanegara street so as to cut road access and in one instance it once also scrapped the asphalt that just recently been layered on, as seen in the bottom right photo.[1] While in most cases flash flood like this tends to be considered as dangerous as it induces severe impacts, unfortunately, the majority of residents in Cigugur Tengah have a rather different opinion as shall be discussed in the following paragraphs.

Figure 6 **Flood stream in Cimahi case**
Source: MoPWH. (2019a)

The severity of flash flood impacts in Cigugur Tengah shown in a fatality where a motorbike driver was drifted by the flood stream and fell into a sewer. In this same location, but at a different time, a car drifted but it did not result in any fatality since there was a safety fence on the border of the sewer. These incidents were recorded on the news quoted below:

[1] idem

"One man died due to being drifted off the overflowing river stream.. (it was) reported that river overflown into the Mahar Martanegara street reaching to a level of 30 cm".[2]

"It happened at about 06.30 AM. The overflow flood goes into the sewer, then he (the victim) seemed to want to pass by (the flood stream) then he drifted, his motorbike went into the sewer, and fell. The motorbike was still here (near the sewer) but he fell, drifted even further. It is common there, when heavy rainfall floods the roads. The victim was found dead approximately 200 meters off the location when he fell, after 30 minutes of search".[3]

Respondents mentioned that there are different flood levels, ranging from 30 cm to more than 1 meter height and with a duration of 30 minutes to 2 hours. Flood incidents have caused light damage of damp to walls and wood frames. When it has receded, flood have left mud and waste for the residents to clean up as been mentioned in the following quotes:

"This river is straight at the upstream then meanders for 90 degrees and narrows. When river overflowing it got into the yard at 50 cm high" (ZR 05)

"Flood comes with mud and the residents clean up straight afterwards. It usually comes with waste or plastics" (F 17).

Figure 7 **Flood hazard** map of Cigugur
Source: MoPWH. (2019a)

Based on the identification of flood hazard, the two cases have different flood characteristics although both can be categorised as flash floods. In Mojo, flood has high frequency but low impact, reaching to average height of 50cm and within 1 or 2 days time span to recede. Flood intensity in Mojo does not damage houses that are made of bricks. In Cigugur Tengah, flood has high frequency and low to high

[2] https://bnpb.go.id/berita/banjir-hanyutkan-satu-warga-kota-cimahi

[3] https://kumparan.com/kumparannews/detik-detik-pemotor-terseret-arus-banjir-di-cimahi-1tGVS68Ty67/full

impact with a height of 50 to 100cm and within several hours of time span to drain. From the interviews, at least two respondent houses and fences, located at a perpendicular of the flood streams, were damaged. These two locations were flooded due to the elevation of their houses being lower than the flood source. In Cigugur Tengah, the drainage and sewerage has insufficient capacity thus flood flows through the road, onto lower elevation through alleys before it finally can be disposed of on the river body. To channel the flood, some residents make holes on the river embankment.

4.2. Adaptive responses

Despite regularly being flooded, most kampung dwellers have got accustomed to floods and made different kinds of adaptations to lessen the risk of loss. Elevated floors, simple flood gates, and ceramic tiled walls have become retrofitting methods for the kampung dwellers.

From interviews and observations, it is known that residents of **Mojo** have adapted to flood by making several adjustments on their houses, such as floor levelling, water barrier, and ceramic tiles on walls. One of the residents uttered:

"Our preparation.. well.. we made floor levelling. At the front door, we raised it by 2 levels (of bricks) at least, to prevent water from coming into the house. For example, if previously the level was 20 cm, kita raised it to 30 cm." (EK)

Nevertheless, figure 8 shows that not all respondents made adaptations on their houses despite the routine and long-existing flood. It seems that the flood is not considered as having high destructive power for the majority of interviewed respondents.

Figure 8 **Adaptation** map of Mojo
Source: MoPWH. (2019)

In the case of a disaster, Mojo has a mix of early warning systems. The traditional warning system utilizes manually operated *kentongan* (drum made from bamboo or wood which is struck to sound an alarm) to give different signals based on type or level of threat. There are four volunteers from the kampung security team who patrol at night and knock on each *kentongan* in case of emergency. Nevertheless, several respondents have said that it has not been sufficient as quoted below:

"Everytime it floods, the sound of *kentongan* is heard 4 times: *tung.. tung.. tung*.. *tung*. It sounds like that, the sound of flood. If there is such a sign, we have to get ready." (PD)

"If there is only *kentongan*, I guess it would not be sufficient … when we were asleep; the sound was not loud enough. If there is a siren and pump, that should help in mitigating (flood) disaster." (EK)

In the past three years, however, there has been an effort to reduce disaster risk, by complementing the traditional *kentongan* with automatic sensors on the river, water pump and embankment.

In **Cigugur Tengah,** there were no respondents who said had to evacuate in the event of a flood. Presumably due to flood being a low threat, for residents who live in two-storey houses they usually evacuate to the second floor. It has been uttered by respondents in the following quote:

"Since flood only comes in short time or passing by, residents who live in two-storey houses usually stay in the house" (F 17)

Corresponding to reaction mentioned above, kampung dwellers of Cigugur Tengah made adaptations to flood by installing flood gate on doors, floor levelling, and propping furnitures. Simple flood gates, made of woods or irons, are usually shut or open adjusting to conditions. In order to keep flood from coming into the house, these gates are found to have different heights adjusting to the flood level experienced by each dweller. Since majority of dwellers have installed flood gates, it seems to work quite effectively in preventing houses to get flooded, as the following respondent's testimony:

"*Dipalang* (by installing flood gates) is sufficient enough because flood in this area only *banjir kiriman* (comes passing by)" (F 17).

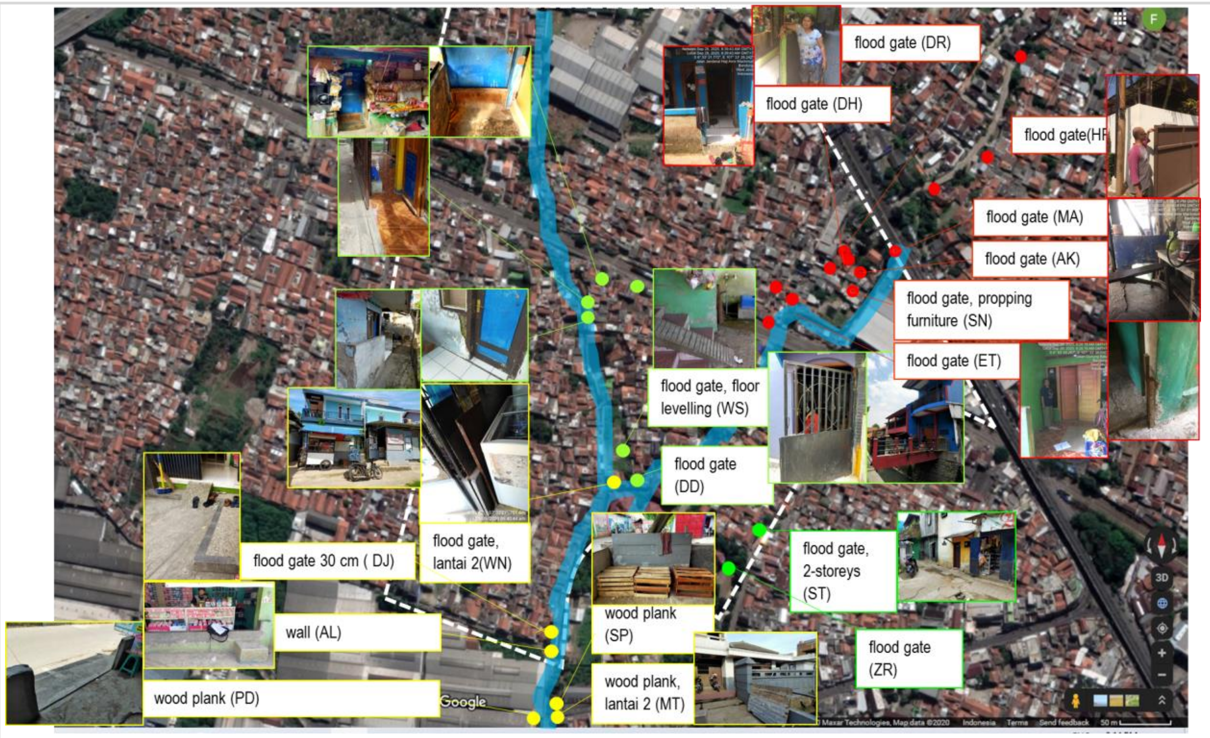

Figure 9 **Adaptation** map
Source: MoPWH. (2019a)

In **Cigugur Tengah**, rather different to Mojo, open spaces are severely lacking amidst the high density of buildings, making alleys so narrow that in some segments can only allow one person or one motorbike to pass through at a time.

Figure 10 **Alleys and spaces in between houses of Cigugur**
Source: MoPWH. (2019a)

With such limited space and narrow alleys, developing evacuation strategies is quite challenging. Officers from the local disaster management agency have mentioned in the quotes:

"When everyone built two-storey houses, and their terraces were built encroaching the alleys.. it is very high density.. disaster risk is pretty high, vulnerability is also high, we are difficult to map the evacuation route.. lack of open space there, it is very rare (to find an open field)" (BPBD)

4.3. Result of modified UNDRR scorecard tools

Index on flood and radar charts of **Mojo** show that with no change in vulnerability, the flood hazard index can be reduced from of 3.33 to 2.40, mitigation-adaptation can be increased to 4.00, and resilience can be increased by 1.23 to reach 2.10. Such change was able to be done with the following scenarios and assumptions: By increasing capacity of sewer, frequency of flood reduced from several times a year to almost never, flood level height reduced from knee-high to less than 30cm, flood drain-off time to less than an hour, flooded area from more than 5 hectares to less than a hectare. Capacity is increased by adding sirens to the warning system, and planning for evacuation routes.

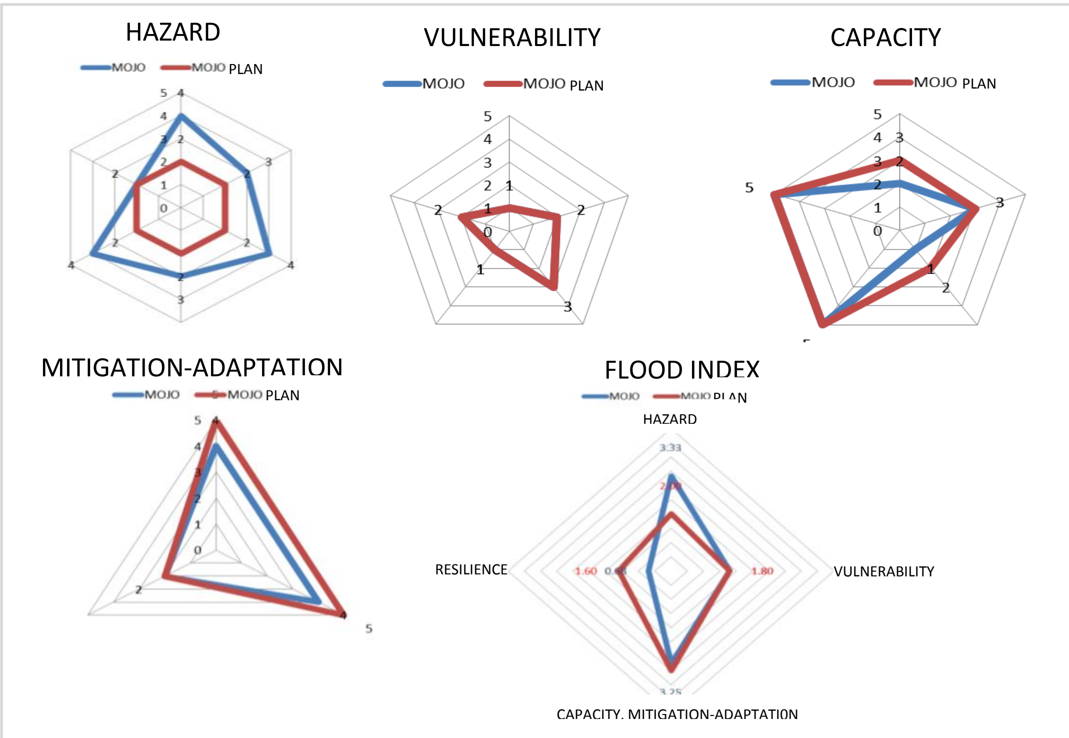

Figure 11 **Flood index in Mojo**

Meanwhile, index on flood and radar charts of Cigugur Tengah show that with no change in vulnerability, the flood hazard index can be reduced from 3.40 to 2.00, mitigation-adaptation can be increased to 3.50, and resilience can be increased to reach 1.30. Such change was able to be done with the following scenarios and assumptions: By increasing embankments area of river and capacity of sewer, frequency of flood reduced from several times a year to almost never, flood level height reduced from knee-high to less than 30cm, flood drain-off time to less than an hour, flooded area from more than 5 hectares to less than a hectare. Capacity is increased by adding a traditional early warning system, assigning evacuation places, and planning for evacuation routes.

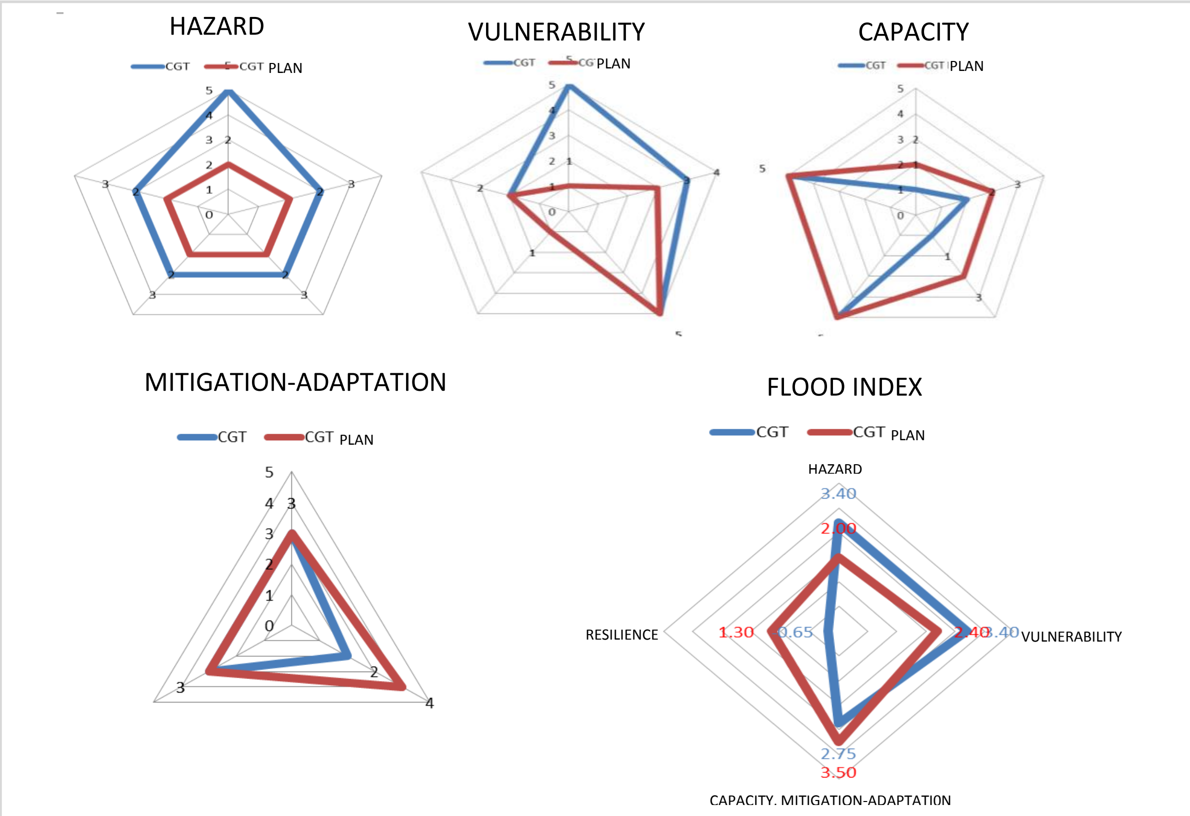

Figure 12 **Flood index in Cigugur**

There are three alternatives of responses to hazard: Adapting to risk, aversing risk, and reduction risk to become mitigation, either by reducing hazard or reducing vulnerability. While residents of Mojo and Cigugur Tengah have shown to adapt, which reduces their vulnerability and risk to flood, it seems that further intervention options are rather limited. Considering the already densely populated area, planning for an evacuation route is possible in the main network of alleys, but it requires great effort. Nonetheless, it should be kept in mind that evacuation and relocation is a last option when hazards reach a certain level of danger so as to threaten people's lives. Another factor to weigh in consideration is the residents' livelihoods. Majority of kampung dwellers are highly dependent on location because they own warung (convenience store) as their source of livelihood. Addressing such factors in planning for disaster risk reduction is crucial, to ensure that residents are able to keep their livelihood while being safe from disaster.

5. Conclusions

Flood, as one of the climate change hazards, has impacted many people throughout the world. While a global plan of disaster risk reduction is in place, by enforcement of land use regulations, implementation of building codes, and preservation of protective eco-systems, it may have not touched the high-density built-up areas such as kampung. With the physical, spatial, and economic limitations of kampung, adaptation is sought as an alternative solution towards disasters. Findings have shown that kampung dwellers have made adaptations to flooding. Elevated floors, simple flood gates, and ceramic tiled walls have become retrofitting methods for the kampung dwellers. Other than structural mitigation, such as increasing the capacity of sewer and river embankment, aspects that may be useful to increase the resilience of kampung dwellers are early warning systems and planning evacuation routes. Although planning an evacuation route is a challenging task, the potential benefits certainly outweigh the effort. In the end, disaster is highly site-specific in terms of how it differs among different climate, topography, socio-economic and spatial characters.

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