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Appropriate flood control technology in a local trading area: Case study at Pulosari Kiosk Area in Malang City

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Abstract

To date, flood is a problem that often plagues the city of Malang. Floods that occur are mainly caused by poor drainage channels and silting of drainage channels due to people's habits of throwing garbage in rivers. In the Pulosari Kiosk Area of Malang city, the flood was worsened by the capacity of the Pulosari Channel which narrowed due to illegal building. In heavy rain, so much water overflowed into the Pulosari Road, resulting in losses to traders in the area. The purpose of this study was to find a solution to reduce flooding in the Pulosari Channel with the appropriate flood control technology in the area. This study used interviews and questionnaires to investigate the community's response to flood control development efforts. Data analysis was carried out using statistical analysis to obtain a description of the community response to a flood control system implemented by the city government. The research results show that constructing flood diversion channels in the upper area, and educating the community about flood risk management is the best solution in this area to minimize flood losses.

Keywords: Community engagement; Flood; Flood control; Pulosari Channel

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1. Introduction

Flood or inundation is one of the natural disasters that occur in almost all major cities in Indonesia during the rainy season. This is caused by several factors including high rainfall, impermeable land covering which causes rainwater run off cannot infiltrate into the soil, lack of public awareness of the environment include flood risk awareness (Franceschinis et al., 2021), lack of drainage system especially in densely populated areas, and lack of law enforcement of city spatial planning (Esmaiel et al., 2022) causes a narrower river section. The narrowing channel can increase the water level (Kiss et al., 2021). Among the factors that

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cause flooding as mentioned before, the change in land use or spatial planning is the main cause of flooding in various regions (Kodoatie & Syarief, 2010). However, people living in disaster areas have shown self-adaptive behavior through socio-economic elements of household characteristics in the form of complex relationships. The understanding of this complexity is useful in undertaking inclusive disaster management initiatives by the government to facilitate the survivors of informal settlers in 'at risk' areas (Dangol & Carrasco, 2019).

Pulosari Kiosk Area, an area of food stalls center in Malang City, Indonesia, which used to be a temporary water storage area and is now turning into a densely populated residential area, frequently experienced flooding and inundation in every heavy rain event. The Construction of kiosks that are also used as a residence violates the rules with buildings jutting into the river. This condition causes the river to become narrower. This is worsened by the development of dense settlements and other facilities that are not balanced with the development of adequate facilities and infrastructure. This has resulted in a lower response of the area to retain the rainwater runoff that impacted flooding or inundation. As a center for street vendors selling a variety of foods, there are several characteristics or criteria that occur naturally in the Pulosari area. In this kind of area, there is a process of interaction between citizen or user approaches and has a role in program design by formulating problems and finding joint solutions in solving problems in the area in an inclusive manner (Tanuwidjaja et al., 2016). An area that is developed as hawker tourism as a tourist attraction should focus on price, people, processes, products, and physical evidence (Praesri et al., 2022). Community participation in street vendors needs to be built because in cases where formal power acts informally, this needs to be taken into account in order to understand the social and economic realities of informal trade and the subsequent barriers to collective action by the urban poor (Lata et al., 2019), particularly for the community who have developed a perception of secure ownership in the settlement, which in turn has encouraged the community to invest in infrastructure and building safe houses (Winayanti & Lang, 2004).

It is necessary to pay attention to the policy implications, including how to calibrate public perceptions about the risk of flooding due to global warming and increase their awareness to take action on climate change (Cheung & Yiu, 2022). Barriers in mobilizing community participation are specific not only in contexts between different countries, but also within countries themselves. Limitations in raising awareness and the role and importance of participation are common problems across the contexts and countries investigated (Fekete et al., 2021; Sugiantiningsih et al., 2019). There is still little involvement of the community at the lowest level because the current governance arrangements do not encourage property-level flood risk adaptation measures. Some factors are simply to secure governance arrangements and prevent a shift in the public-private gap. The need for increased sense of responsibility among private actors needs to be realized. Based on the results of interviews, documentation studies and adaptive expectations, the community sees public authorities as responsible for flood risk management and trusts their expertise and flood technical infrastructure (Rauter et al., 2020).

The impact of floods can result in losses to society and the environment, so that the participation of the community and government is needed in flood control (Sedyowati et al., 2020; Wahyuni et al., 2021). To anticipate flood disasters, an appropriate flood control system should be applied in the area. Therefore, the aims of this study are to describe how much loss is experienced by the community due to the maximum flooding that occurs, and the participation of the community in flood control which is most suitable to be applied in the Pulosari Kiosk area, Gadingkasri Sub-district, Klojen, Malang City through the construction of infrastructure and facilities.

2. Method, Data, and Analysis

This research was conducted in the Pulosari Kiosk Area, Gadingkasri Village, Klojen District, Malang City. Summarily, this research starts gradually from requesting permission for research then continued to the research process itself.

Exploratory approach method is used to gain an understanding on the flow of the Pulosari River directly. Study and research are conducted either through interviews with local residents or related agencies, questionnaires, and also direct observation. This research is descriptive analytical, which describes theories related to problems in the Pulosari river flow, specifically in case of flooding, to then be analyzed based on the reality. The analytical results then used as basis for problem solving.

The population of this research is the people who live around the Pulosari River. The sampling method used is the Cluster Sampling method. Consequently, the population then specifies into residents of the Pulosari Kiosk, Gadingkasri Village, Klojen District, Malang City. The respondents were the residents of the Pulosari Kiosk who were affected by the flooding, whose home is near the Pulosari River. The number of respondents taken is 40 respondents representing the entire population and has been able to form a normal distribution. Therefore, this study is using primary data, based on data used. Data collection method used are observation, interviews, questionnaires, and documentation. The variables in the study are shown in Table 1.

Table 1.
Variable and data source

Variable	Data Source
Cause of flood	Interviews/questionnaires with/from locals
Community participation/role in flood control system	Interviews/questionnaires with/from locals

This study uses a quantitative analysis technique mentioned as quantitative descriptive analysis, which the results will in accordance to the reality. The first step is to create a frequency table and then complete with a percentage. The data will be processed using Microsoft Excel.

3. Results

Observations were carried out in the Pulosari area with the plan shown in Figure 1.

Figure 1. Plan and distribution of respondents.
Source: Google Earth

Respondent Profile

The majority of respondents have lived in the area for a long time. Of the 27 questionnaires distributed in the Pulosari Kiosk Area, the percentage of female respondents was 14.8%, while male respondents dominated with a percentage of 86.2%. The results obtained for the respondent's age information is that the age of 30-50 years is the dominant age in the survey that has been carried out with a percentage of 44.5%, and the age of 20-30 years is the smallest, with percentage of 25.9%. From the survey results on the education level of residents around the Pulosari River, it was found that the dominant ones were SMA/SMK graduates with a percentage of 37%, and elementary school graduates were the smallest percentage. The occupations of all respondents are traders, with a percentage of 100%. This is because the area is a trading area. The location of 100% of respondents' houses/kiosks is close to the river, with 0% of respondents owning houses/kiosks that are far from the river. From the survey results, it was found that 85.2% of Pulosari residents have a fairly large kiosk building and in the northern area there are four small shop houses.

Conditions Related to Flood Problems in the Research Area

Flood discharge

Flood discharge means a calculation between water level and river discharge in the study area. There are several ways to determine river discharge in the study area, one of them is by direct measurement in the field. The results obtained by direct measurements in the field are shown in Table 2.

Tabel 2.
Flood discharge

H(m)	Q(m3/dt)
0.1	0.08
0.35	0.9
0.4	1.2

Source: Observation data

Flood height

From the survey results and respondents, floods that occur in the Pulosari river area with water levels could reach 2-3 meters (if heavy rain occurs). The overflowing water can reach Pulosari street to Pandan street and disrupt the activities of residents.

Factors that cause flooding

From the survey results on the factors causing flooding, combined with the perception of the people who were directly affected by the flood in the Pulosari river area, RW 4 Gadingkasri area, it was found that the major factor causes the flooding was residents from the upstream part mostly threw their garbage into the river. In addition to this, there are respondents who stated that if the flood occurred because the community stated that the construction of houses that could limit waterways, and reduce the capacity of the river's capacity. Kodoatie & Syarief (2006) explained that the factors causing flooding are change of land use, waste disposal, erosion and sedimentation, slum areas along rivers, inappropriate flood control systems, high rainfall, river physiography, inadequate river capacity, the influence of water. tide, land subsidence, water structure, flood control building damage.

Loss due to flood

Floods with an average height of more than 2-3 meters cause certain impacts and losses in the area. Not only material losses, moral losses are also suffered by the community. However, the flood disaster was not felt by the people who were in the upstream area of the Wilis road area. This is because the upstream area has a river pattern with a deeper base and a wider river dimension, which causes floods not to reach the road. The following are the losses received by the community in the Pulosari area due to flooding.

Material loss

Material losses were experienced by people in the Pulosari kiosk area. The majority of respondents in the Pulosari kiosk area suffered losses from damage to household and public facilities and infrastructure such as roads, sidewalks and others which resulted in a decline in the economy of the community in the area.

Moral loss

The moral loss was also felt by residents in the Pulosari kiosk area. This can be seen from the survey results that the majority of respondents in the area have a sense of trauma to the threat of disease due to dirty river conditions. If the flood occurs with a height of more than 3 meters, it will cause a sense of trauma to the residents. Table 3 shows the maximum flood losses in the study area.

Table 3.
Maximum loss due to flooding

Main Sector	Subsector	Damage Level			Loss	
		Mild	Moderate	Severe		
Social sector	- Schools	√	-	-	Rp.	100.000,-
	- Mosque	√	-	-	Rp.	300.000,-
Infrastructure sector	- Bridge	-	√	-	Rp.	1.000.000,-
	- Road	-	√	-	Rp.	3.200.000,-
	- Drainage	-	√	-	Rp.	2.000.000,-
Productive sector	- Trade Services		√		Rp.	3.500.000,-
Global impact	- Environment		√		Rp.	500.000.,-

Source: Interview and questionnaires results

Community efforts in overcoming previous floods

Based on the results of research conducted, data obtained 18.5% of respondents doing activities against the flood disaster that occurred. However, the majority of respondents did not carry out activities to overcome flooding. Prevention activities were carried out by 18.5% of respondents by making fences or nets on the river to stem the garbage that was dumped by the people upstream into the river. Still, this prevention method cannot cope with flooding in the long term, it can even cause flooding in the upstream area.

Government efforts in overcoming previous floods

Based on the data obtained from the government, the efforts made are by making flood control buildings in the form of embankments. However, the efforts that have been implemented by the government are still not the right solution for flood prevention.

Wishes of the people affected by floods

With conditions that are vulnerable to flooding, people living in the Pulosari river area really hope that the government will immediately implement a flood control program to be able to solve this problem. The government does not have to carry out evictions or demolition on a large scale, knowing the area is a trading area. If the demolition is carried out, the residents agree, but only with partial demolition, in the hope that it will not cause major damage.

Suitable Flood Control System for the Research Area

Embankment Method Analysis

The embankment method is a flood control method by raising the soil elevation on the riverbanks with the aim that the water does not pass through the banks (FEMA, 2001). According to (Kodatie and Sugiyanto, 2002), the embankment serves to localize flooding in the river and to increase the accommodated water discharge, so that it does not run over to the right and left of the river which is an allotted area.

The embankment that must be built to overcome the flood problem that occurred in the Pulosari area is 2.5 meters high. According to the results of interviews with residents, the flooding frequently reached 2 meters.

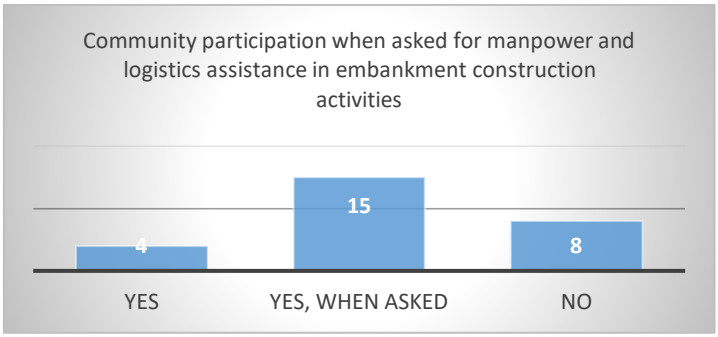


Figure 2. Community participation willingness in embankment construction
Source: Questionnaire results

Based on Figure 2, Pulosari Kiosk residents who answered yes (14.8%), yes when asked (55.6.5%), no (29.6%). Because of most residents will help whenever asked, the government must cooperate with or involve citizens so that citizens also participate in these activities.

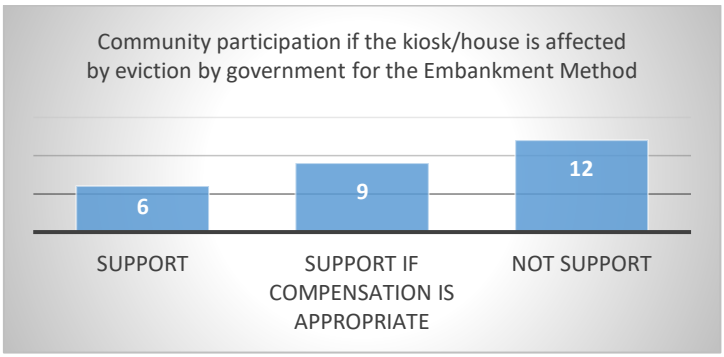


Figure 3. Participation of residents affected by the eviction program
Source: Questionnaire results

Based on Figure 3, the percentage that dominates is 44.5% not supportive, because these residents have been living in the area for a long time to trade. Most of the residents who support have a fairly high education and understand about the regulations of settlement on the banks of the river and importance of flood control for good in the future.

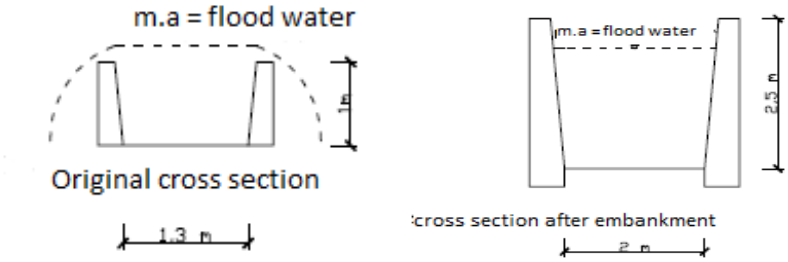


Figure 4. Original cross section
Figure 5. The condition of the cross section after being given the embankment
Source: Personal documents

Analysis of the River Normalization Method

Normalization or river restoration is to restore the size of the river that has narrowed its cross section, as well as the depth of the river according to its initial condition. According to Kodotie & Sugiyanto (2002) river normalization or restoration is aimed at increasing the river's capacity and facilitating the flow. Because the data on the width and depth of the Pulosari river at the initial conditions are unknown, the river restoration method will be carried out until the condition is that there will be no more flooding.

Based on the flooding that occurred in the Pulosari river, the current width of the river is only 1.3 meters and the depth is only 1 meter, the channel is unable to accommodate the water discharge. To overcome the flood, the depth and width of the river must be expanded. The depth of the Pulosari river can be dredged as deep as 50 centimeters. While the channel width can be widened to 2 meters. This also means that the City Government must demolish the houses or kiosks of residents as wide as 2 meters from the current riverbank.

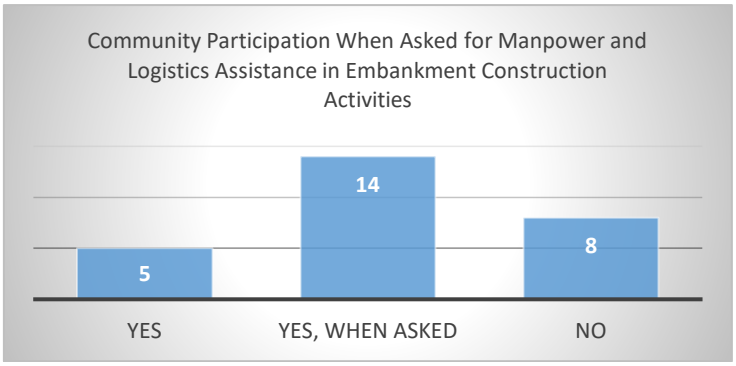
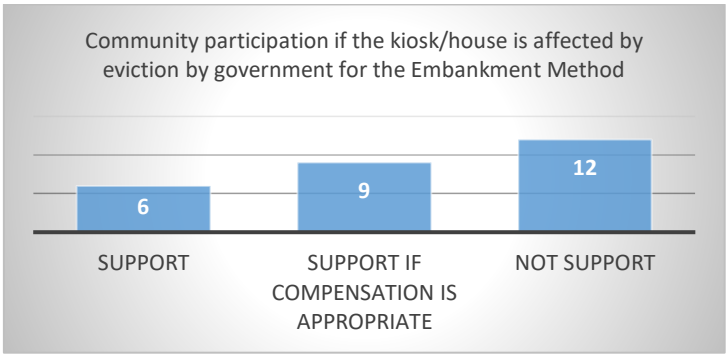


Figure 6. Community participation in the normalization method
Source: Questionnaire results

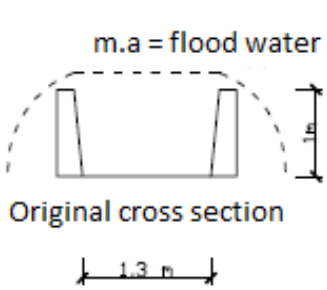
Based on Figure 6, Pulosari Kiosk residents who answered yes (14.8%), yes when asked (55.6.5%), no (29.6%). Because the answer that dominates when asked. The

government must cooperate with/involve citizens so that citizens also participate in these activities.



Gambar 7. Participation of residents affected by the eviction program
Source: Questionnaire results

Based on Figure 7, the percentage that dominates is 44.5% not supportive, because these residents have lived in the area for a long time to trade. Most of the residents who support have a fairly high education and understand about the rules of settlement on the banks of the river and the importance of flood control for the good in the future.



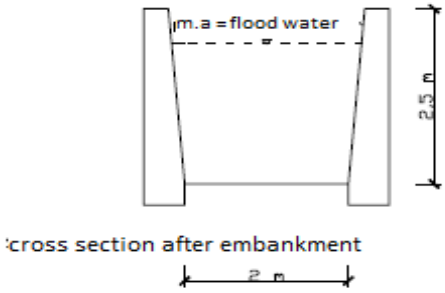


Figure 8. Original cross section
Figure 9. The condition of the cross section after normalization

Analysis of the Method of Making Infiltration Parks and Community-Based Educational Parks

One of the flood prevention methods that have a high effectiveness is infiltration and education parks. The flood prevention system applied to the infiltration park is the bioretention method, where vacant/abandoned land located in Pulosari is processed in such a way as to be able to absorb water from floods quickly, and then the water is processed to provide benefits again.

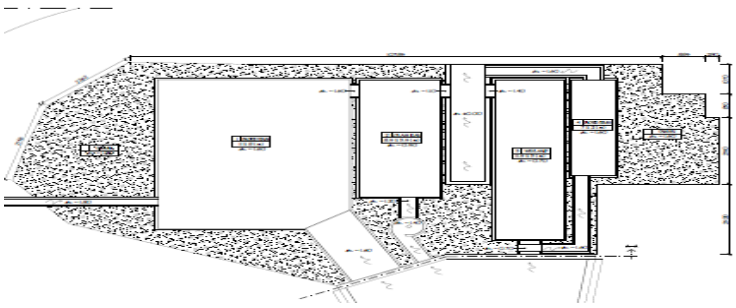


Figure 10. Infiltration and education park plans

The infiltration parks and education are not only beneficial in terms of the effectiveness of flood control, but also from proper flood water treatment which can provide excessive benefits to the Pulosari community itself, as well as the general public. The water treatment mentioned can be in the form of treating flood water which is generally dirty, then through several processes it will become clean water that can be used as fish ponds, fruit and vegetable gardens, as well as being the main water source for all plants in the park location. Not limited to bioretention methods, the construction and development of infiltration parks and education, used following methods:

Bioretention

Bioretention comes from the word bio which means living things and retention which means to store. The application of bioretention facilities can be carried out in several places including residences, parking areas, toll roads, public places and so on.

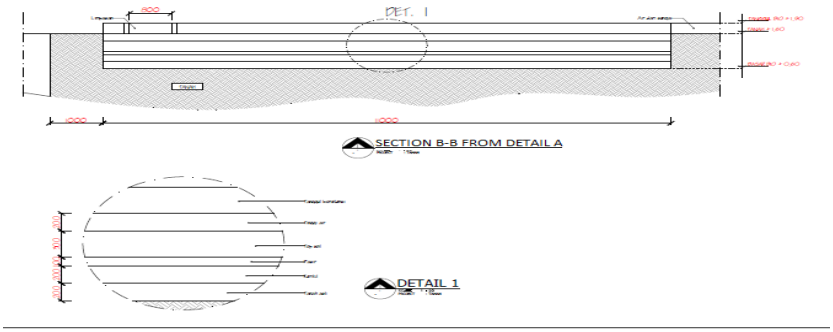


Figure 11. Bioretention layer structure and benefits

There is bioretention at the park that is useful for dealing with flooding, with bioretention of water can be accommodated in the bioretention layer, then water is flowed into the ground, in the top soil can be planted with plants that are useful for residents in the form of vegetables and ornamental plants.

Microhydro with Catfish Pond Output

In addition to using the bioretention method, there are other methods for dealing with flooding in Pulosari, namely the micro-hydro method with catfish ponds as output. Micro hydro is one method that allows water to produce alternative energy which then becomes electricity. The water that enters the input of the micro hydro channel is processed in such a way that if the water enters it is less clean water. After being processed in a micro-hydro system, the water will become suitable as a medium for catfish cultivation. In the end, catfishes can be useful for Pulosari residents.

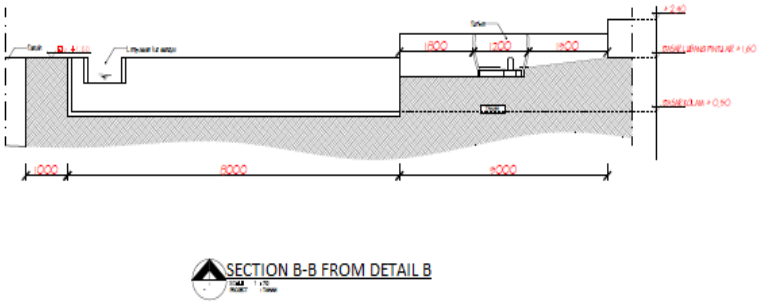


Figure 12. Microhydro and catfish pond

Wetland

Constructed wetland is a wastewater treatment system that uses simple technology with a new approach to reduce environmental pollution based on the use of aquatic plants and microorganisms. Aquatic plants in artificial wetlands have a role in providing a suitable environment for decomposing microbes to attach and grow. The advantages of this system are that it is simple in construction without tools and machinery, relatively inexpensive to operate and maintain, and has a large buffer capacity and low and stable sludge production.

In making wetlands in the park area, it is very functional because people who dump a lot of domestic waste into rivers cause pollution to occur. Then the water that flows downstream does not experience environmental pollution.

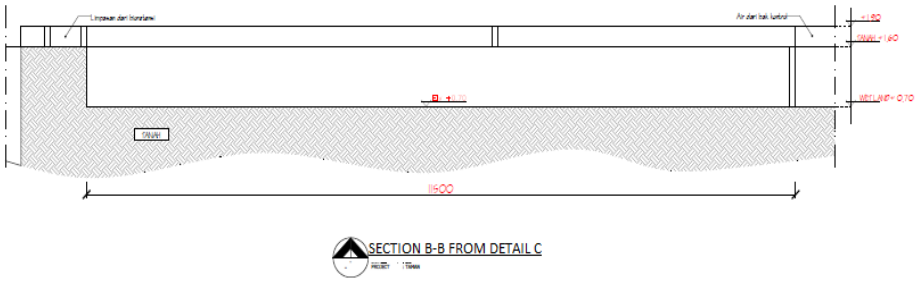


Figure 7. Wetland

4. Discussion

The survey results show that 100% of the people in the Pulosari area have a livelihood as traders, dominated by male in the age range of 30-50 years, and all of them live in the trading area. This data indicates that the people in Pulosari are at mature age in decision-making, especially with the status of the head of the family, predominantly by men. The kiosk that is used as a place to trade is also used as a residence. Assuming one family contains 4-5 people, the standard kiosk which was originally 3 x 2 m has been renovated to be 6 – 10 meters long. The informal design of the house modifications caused development in the area to become out of control. These results support the results of research on the redesign of a street vendor area for the sustainability of the area in the future (Tanuwidjaja et al., 2016).

Uncontrolled modification of Kiosk buildings causes river narrowing which has an impact on the increase in river water level exceeding the planned water level so that it has the potential for flooding. This condition is exacerbated by the presence of a place of worship that crosses the river with the base elevation of the building equal to the normal water level. This is the cause of the narrowing of the river cross section and makes this area a flood-prone area. This result is in accordance with the results of the study which concluded that the narrowing of the channel by 9% caused an average increase in water level of 10% (Kiss et al., 2021).

This study aims to provide an alternative solution to the flood problem in the Pulosari street vendor area by using appropriate community-based technology. The concept of community-based technology involves the community from the planning stage (Chowdhooree et al., 2020), implementation, operation and maintenance of technology. Community participation is generally more focused on the use of soft engineering or non-structural technology that has a significant effect on reducing flood losses (Nugraheni et al., 2022). Therefore, in this study, rain infiltration park technology was developed using the concept of bioretention technology. This technology is one of the flood prevention methods that has a high effectiveness because it is easy to manufacture, operate and

maintain, and provides significant results (Nasrollahpour et al., 2022). The application of this technology at the study site utilizes vacant land in the Pulosari area. The land is processed by changing the soil structure according to the standard bioretention layer so that it can absorb water from rainwater quickly, and then the water is processed so that it can provide benefits again. The water that seeps into the land is beneficial for plant growth in the form of vegetables such as chili, eggplant and tomatoes, while the water that runs off the surface will be directed to a channel, which is then used for catfish farming. "Terong, lele, lombok, dan tomat" (eggplant, catfish, chili, and tomato) is known as the "Telolet Om" Program. This mechanism will provide benefits to the community, including financial benefits as has been implemented in the Glintung Water Street area (Sedyowati et al., 2020).

5. Conclusion

There are several conclusions based on data collection and analysis that has been done. From the results of interviews and questionnaires, it is known that residents have suffered losses. Because the area is a trading area, if there is a flood to the Pulosari road, the income of the residents will decrease. The road cannot be passed by vehicles because the flood can reach 50 centimeters or even more. Floods also damage existing infrastructure such as roads, sidewalks and others. And the maximum flood losses experienced by the Pulosari community can reach Rp. 10,600,000,-. The role of the community in this flood control system is very much needed because residents are one of the influential parties in flood control. With public awareness, the community can not only be the party causing the flood disaster, but can provide solutions to the flood disaster. According to the survey results, the prior efforts of the flood control system by means of normalization and embankments were not very appropriate due to the resistance from residents. With the infiltration and education park it is possible to develop alternative methods of flood control that can be more accepted by the community, because residents receive many benefits from the park, such as economic and educational benefits.

Based on the data collection and analysis conducted, there are suggestions and recommendations for the government and the community. The local government is expected to be able to overcome the problem of garbage and buildings on the banks of the river so that it can be more emphasized in enforcing the law and provide socialization about the importance of protecting the environment. In this case, the community must also know the applicable laws regarding riverbank development and maintaining flood control buildings. Residents should make efforts to maintain environmental cleanliness, namely activities or efforts in the form of not throwing garbage in rivers, not throwing domestic waste in rivers, and so on.

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