 https://doi.org/10.1051/bioconf/20248908001

Rapid Assessment for Emergency Infrastructures in Responding Flood related to Mining Activity: Case Study of Banjarasri and Kedungbanteng Flood, Sidoarjo, Indonesia

Adjie Pamungkas[1*], Ita Elysiyah[2], Gita Rama Mahardhika[3], Yanwa Evia Java Mauludya[3], Dian Rahmawati[4], Santi Wahyuni[5]

[1] Department of Urban and Regional Planning, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
[2] National Land Agency of Pasuruan City, Pasuruan, Indonesia
[3] Development Initiatives for Indonesia (DIFI), Surabaya, Indonesia
[4] Department of Geography, Spatial Planning, and Environment Radboud Universiteit Nijmegen, The Netherlands
[5]Department of Nursing, Politeknik kesehatan Kemenkes Tasikmalaya, Indonesia

*E-mail: adjie@urplan.its.ac.id

Abstract. Flooding has become the most frequent and impactful disaster events in the Indonesian cities. The Indonesian disaster board also noted that flood events has increasing pattern for today and future time. One of the strategic ways to decrease the impact of flooding is delivering the emergency infrastructures to the needs immediately. The faster delivery makes less impact of disaster events. Therefore, this paper synthesizes a rapid model of assessment from the full assessment of emergency infrastructure need in Sidoarjo Flooding 2020. During the synthesize, the model can reduce duration of assessment from 148 days to four days only. Within the time, eight main steps include finding relevant emergency infrastructures, determining emergency infrastructures needed, assessing emergency infrastructures needed and confirming the actual emergency infrastructure needed. Those eight steps should be taken by encouraging more FGD and in-depth interviews for key relevant stakeholders, guided by specific checklist and filling the gap forms. Strict forms and guidelines provided to help the process in achieving four days assessment period. Consequently, the authorities can use the output assessment for emergency infrastructure program delivery starting from the fifth days after the events. *Keywords: emergency infrastructure, rapid assessment, flooding, program delivery.*

1 Background

Flooding is part of the global disaster event including in Indonesia. Floods have affected 1.8 billion of people in recent decades[1,2]**.** Such large-scale flood events, [3] explained that the effects cover extensive regions, encompassing several thousand square kilometres and numerous watersheds, resulting in significant direct impacts at both the national and regional levels. Furthermore, flood is the most frequent type of disaster, 43% of all recorded hydrological, meteorological, climatological, and geophysical events with reported flood losses amounting to 661 billion USD [4]. Disaster Database of Indonesia (DIBI) [5] also noted that the 598 number of flood events with 9.462 victims were evacuated, and a total of 83.613 people were affected by the flood disaster during 2022. Moreover, a changing global climate exacerbates the flooding and its impacts [6]–[8]**.** To some cases, the flooding is simple due to poor drainage system such as in Sarawak, Malaysia [9] and Ogun, Nigeria [10] or unpredicted volume of rainfall such as in Attica, Greece [11] and Mar Menor, Spain [12]. Especially for the case of Banjarasri and Kedungbanteng in Sidoarjo-Indonesia, the flood is caused by the land subsidence due to mining activities [13]. Areas exhibiting concerning levels of ground deformation, indicating they are "at-risk," are located around the Lapindo region and extend towards the northern part of Sidoarjo. [14].

Sidoarjo Municipality located in southern part of Surabaya, the capital city of East Java Province. The development of Sidarjo accommodate the spill over of Surabaya development causing a high pressure of land use change to build up areas for about 37,977% in 2020 where in the period 2009 – 2020 the conversion of green land into growth occurred of 6,032,694 Ha [15]. Other core economic activity is oil and gas mining that has contribute 156.799.810.000 Rupiahs or 0,11 % of the total Sidoarjo's gross domestic product (GDP) [16]. In 2006, an industrial accident from Lapindo Mining ltd. occurred, causing a mud volcano that, to this day, has submerged 19 villages spread across 3 districts, with the estimated affected area reaching 1.143,3 hectares [17]. A further impact on Lapindo Mud Vulcano is a vulnerable land subsidence in Surrounding areas including in Banjarasri dan Kedungbanteng [18]. Banjarasri and Kedungbanteng is located around 2-4 km from the Lapindo Mud Volcano to the northeast. The land subsidence in those two villages occurs 2017–2021 for about 200 mm/year. The land subsidence has caused a changing on water flow in drainage and irrigation systems causing flooding [13]. The flooding in the two villages has 30-50 cm depth with two months duration. The flooding occurs only after the land subsidence starting at 2019 [19].

Regional Board for Disaster Management (BPBD) Sidoarjo [20] has also calculated the losses of flooding for about IDR 99.4 billion covering the damage to various facilities, both infrastructures built by the government and those owned by residents, economic losses, and other sectors. Damage and losses borne individually in the economic and residential sectors amounted to IDR 65 billion (65 percent), where each family bore a loss of IDR 130 million. The long duration and high intensity of flooding has also caused a disruption the villagers' daily activity. To cope with the daily activities, the villagers need emergency infrastructures. A rapid assessment of the emergency infrastructures is needed to make sure that their livelihood can be still fulfilled during the flood situation. At this stage, there is no standard assessment on emergency infrastructures causing a lack of providing emergency infrastructures to the victims. The government has a Pengkajian Kebutuhan Pasca Bencana (JITUPASNA) standard that calculates the impact of flood for the recovery process. Therefore, this paper aims to formulate a rapid assessment model as part of emergency responses after the disaster event.

2 Method

In formulating the rapid assessment, five key steps reflect the full assessment to be the main steps. **Figure 1** shows how the methods in this study work, which initially, the literature review identifies potential infrastructures needed during emergencies. An in-depth interviews justify the relevancy of all potential infrastructures for the case study. Content analysis (CA) then assesses the operational status of these infrastructures during flood conditions.

Observations and in-depth interviews provide empirical data on the current state and effectiveness of these infrastructures. Finally, focus group discussions (FGD) integrate all these insights, facilitating a collaborative platform to confirm and refine the findings. This integrative approach ensures that the conclusions are not only based on theoretical knowledge but also grounded in practical realities and stakeholder perspectives, leading to well-informed recommendations for emergency infrastructure provision and management.

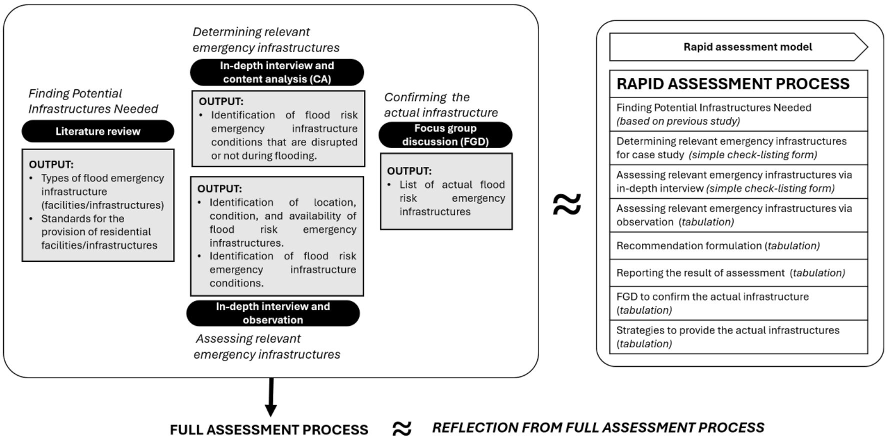

Fig. 1. Analysis methods

2.1 Literature review

Literature review method involves an extensive examination of existing literature, encompassing key academic papers, government policies, standards, and documented best practices relevant to these concepts [21]. The purpose of this meticulous review is to gather, analyze, and synthesize information on potential infrastructures for flood emergencies. The literature are from two main concepts that are residential housing and flood risk management.

2.2 In-depth interview

In-depth interview involves conducting detailed, focused conversations with a select group of respondents, identified through purposive sampling combined with stakeholder analysis, to accommodate the constraints of limited time and access [22]. These questions aim to investigate respondents' perceptions and experiences, providing deep insights on the relevant emergency infrastructures [23]. In this study, the in-depth interview applies to limited respondents based on purposive sampling methods. The output of interview provides perceptions and preferences of stakeholders on the conditions and problems identified about the flood emergency infrastructures.

2.3 Content Analysis (CA)

The method of CA is used to uncover the insight from the in-depth interview. It directs to differentiate between disrupted and well-operating infrastructures during emergency situations, particularly flooding. This analytical approach involves a thorough examination of various infrastructure elements to assess their operational status under emergency conditions [24]. In this study, by scrutinizing the data and information related to the status of condition for every related infrastructure.

2.4 Observation

This method involves a detailed comparison of the current infrastructure conditions against established minimum standards as outlined in relevant guidelines. By doing so, it helps in identifying the gaps. Moreover, the observations gathered are integrated with insights obtained from in-depth interviews, enhancing the understanding of both potential and existing problems [25].

2.5 Focus Group Discussion (FGD)

FGD method is utilized as a crucial step in determining key aspects of implementing the identified emergency infrastructure solutions. Specifically, FGDs are conducted to collaboratively decide on the implementation time component, identify the subjects responsible for the implementation, and determine the sources of funding [26]. This method involves bringing together key stakeholders, including representatives from relevant government bodies, affected communities, and other pertinent entities, to engage in structured discussions [27]. This collaborative approach ensures that the final plan for infrastructure implementation is well-informed, realistic, and enjoys a broad base of support from all involved parties.

3 Result and discussion

3.1 Finding potential infrastructures needed

The literature review analysis was conducted from two main concepts that are settlements/residential housing infrastructures and flood risk emergency management infrastructures. Within those two concepts, we highlight some key literatures, government policies and standards, and best practices. Table 1 shows the potential emergency disaster infrastructure during the flood events. Those infrastructures are potentially to be a long list of emergency infrastructure for general cases. A further assessment need for a more contextual study to justify the relevant emergency infrastructures for a specific case study.

Table 1. Potential Flood Emergency Infrastructures

Housing Infrastructures Concept	Flood Risk Emergency Management Infrastructures Concept	Conclusion on Flood Risk Emergency Infrastructures
Local Street [28], [29]	Transportation [30]	Transportation
Potable Water [28], [29]	Clean Water and Potable Water [30]–[32]	Clean Water and Potable Water
Drainage dan Flood Controller [28], [29]	Flood Control Infrastructures [31]	Flood Control Infrastructures
		Drainage
Wastewater Management [28], [29]	Sanitation [30]	Sanitation
Waste Management [28], [29]		Waste Management
Fire Protection [28], [29]	Fire Extinguisher [33]	Fire Protection
Green Open Space [34]	-	Green Open Space
Educational Infrastructures [34]	-	Educational Infrastructures
Health Infrastructures [34]	Health Infrastructures [33]	Health Infrastructures
Public Service Infrastructures [34]	-	Public Service Infrastructures (Community Kitchen)
Commercial Facilities [34]	-	Commercial Facilities

Housing Infrastructures Concept	Flood Risk Emergency Management Infrastructures Concept	Conclusion on Flood Risk Emergency Infrastructures
Electricity and Lightning [35], [36]	Electricity [33], [37]	Electricity
Telecommunication [35], [36]	Telecommunication [30]	Telecommunication
-	Emergency Operation Post [38]	Emergency Operation Post
-	Shelters [33]	Shelters

3.2 Determining relevant emergency infrastructures for case study

The purposive sampling is conducted to the Head of Village of Kedungbanteng and Banjarasri), and the Head of affected neighbourhood unit (RT) to reflect 1.606 civilians. In terms of the questionnaires, we highlight the condition each infrastructure through an in-depth interview. Later, the result of the in-depth interview analysed using the content analysis to evaluate the condition of every relevant emergency infrastructure.

3.2.1 In-depth interview

In this case, 10 respondents were purposefully selected to represent two distinct categories: government-level representatives and affected civilians. The list of respondents based on category and their availability in this study is shown in **Table 2.** The purposive sampling is conducted to the lowest government-level of representatives (the Head of Village of Kedungbanteng and Banjarasri) and to the affected civilians represented by the head of RT.

Table 2. List of respondents

Category	Respondent	Number of Respondents
Government-Level Representative	Head of Kedungbanteng Village	1
	Secretary of Banjarasri Village	1
	Village cooperation agency (BKD) of Kedungbanteng Village	1
	Village Consultative Body (BPD) of Banjarasri Village	1
Affected Civilians	Head of affected RT in Kedungbanteng Village	3
	Head of affected RT in Banjarasri Village	3
	TOTAL	**10**

The inclusion of the Head of Kedungbanteng Village, Secretary of Banjarasri Village, Village cooperation agency (BKD) of Kedungbanteng Village, and Village Consultative Body (BPD) of Banjarasri Village ensures a comprehensive understanding of governmental perspectives. Simultaneously, the inclusion of civilians from both Kedungbanteng and Banjarasri Villages provides valuable insights into the perspectives of those directly impacted by the flood at hand.

3.2.2 Content Analysis (CA)

In the study, infrastructures are categorized into two groups based on their operational status during flooding. Disrupted infrastructures include transportation, clean water and potable water, flood control infrastructures, sanitation, waste management, health infrastructures, public service infrastructures (such as community kitchens), emergency operation posts, and shelters. These are the infrastructures that face operational challenges during flood conditions, impacting their ability to serve the community effectively.

On the other hand, infrastructures that continue to operate well during flooding are fire protection, green open spaces, educational infrastructures, commercial facilities, electricity, and telecommunication. These infrastructures maintain their functionality despite flood conditions, thereby continuing to provide essential services. **Figure 2** shows the infrastructures that are disrupted and operating well during flooding.

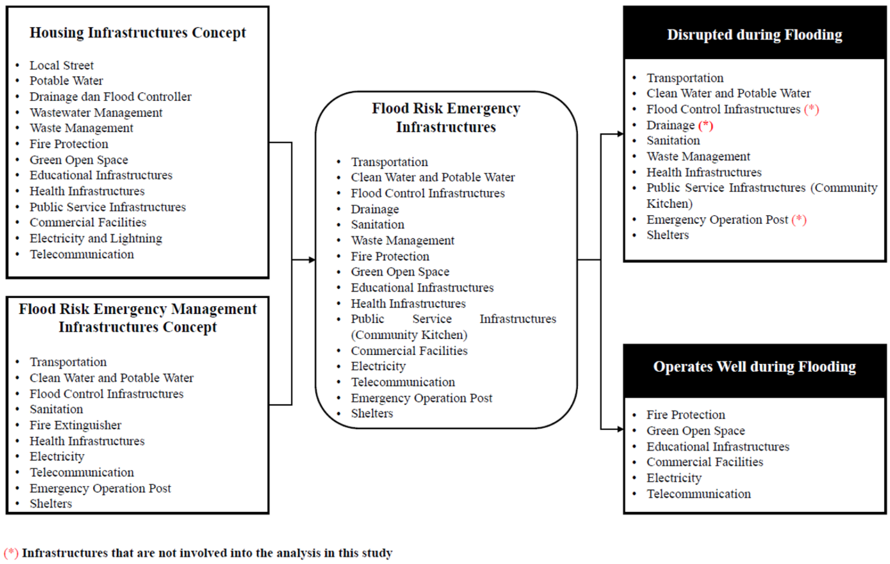

Fig. 2. Determining the relevant emergency infrastructures for the case study

3.3 Assessing relevant emergency infrastructures

The relevant emergency infrastructures are assessed through two main steps: in-depth interviews and observation.

3.3.1 In-depth interview

The first process of identifying the condition of emergency infrastructure was carried out with in-depth interviews with interviewees were 10 stakeholders involved in the previous process. Questions in this process are developed from the keywords listed in **Table 3**.

Table 3. Keywords for in-depth interview questionnaire

No.	Indicator	Keywords for Questions
1	Clean water and potable water	Clean water sources, clean water needs, water quality, water supply during floods
2	Sanitation	Sewage treatment system, household sanitation, condition of toilets and septic tanks during flooding, alternative toilets / toilets, availability of communal toilets
3	Waste management	Availability of TPS, availability of waste infrastructure, waste conditions during flooding

No.	Indicator	Keywords for Questions
4	Health infrastructures	Availability of health facilities, condition of health facilities, health services during floods, sensitivity to types of diseases during floods
5	Community kitchen	Availability of community kitchens, conditions of community kitchens
6	Shelter	Availability and location of shelters, shelter conditions, facilities in shelters, shelter capacity
7	Transportation	Road and vehicle conditions during flooding, availability of alternative roads, alternative transportation during flooding

In general, all indicators have similarities related to the source of infrastructure provision, the condition and availability of infrastructure during flood emergencies, and the availability of alternative solutions.

3.3.2 Observation

The results of these observations are then juxtaposed with the identification of potential and problems obtained from the in-depth interview process to formulate the types of activity recommendations and the points of implementation of the recommendations accordingly. The implementation of these observations refers to the observation guidelines shown in **Table 4**.

Table 4. Example for instrument of observation regarding transportation indicator

Variable	Sub-variable	Minimum Standard/ Parameter	Condition		Documentation/ Information
			Appropriate/ Exist	Inappropriate /None	
Service network	Road width	Collector road width 7 m			
		The width of the neighborhood road between settlements is 4m			
		Secondary local road width 3-7 m			
		The width of the neighborhood road of the settlement center with the center of the neighborhood I is 1.5-2 m			
		Width of the central neighborhood road of neighborhoods I to II 1.2 m			
	Road network connectivity	Connectivity between existing road networks			
	Road furniture	There are street lighting			
Road surface quality	Road surface condition	Perforated/not perforated			
	Pavement condition	Pavement/ashpalt			

The results of the interview and observation process are used to map actual problems in the field and existing potential. These findings were categorized into four classes based on their severity, namely: (1) slight damage; (2) moderate damage; (3) severe damage or missing; and (4) none.

Table 5. List of actual condition, impact category, and potential for emergency infrastructure

Indicator	Actual conditions	Impact category	Potential
Clean water and potable water	The main water source of residents in both villages during normal conditions comes from wells. When flooded, the water from the well turns dirty/turbid so it is not suitable for consumption of daily activities.	Severe damage or missing	The existing potential of clean water and potable water provision, namely: 1. There are several alternatives to clean water during floods and their supporting infrastructure (mobile clean water sellers and shared reservoir water). 2. There are already several water reservoirs managed by residents. 3. In the early 2020 flood, there was clean water support from PDAM using tank vehicles filled with clean water
	Unserved by PDAM pipeline network	None	
Sanitation	1. Residents' private toilet cannot be used during flooding (submerged). 2. The public toilets are located next to a very flood-prone river. 3. Many public toilets are damaged.	Severe damage or missing	The existing potential of sanitation infrastructures, namely: 1. There are 6 public toilets spread across the two villages affected by the flood. 2. In early 2020, there were already portable toilets in each RT from the government.
	1. Residents feel that portable toilets that have been given are not comfortable because there is little water 2. Public toilets are not enough to serve all flood victims	Moderate damage	
Waste management	1. Banjarasri Village does not yet have TPST 2. Some residents of their waste management were burned	None	The existing potential of waste management infrastructures, namely: 1. There is a TPST at RT 07 Kedungbanteng 2. There has been garbage transportation every 2 days in Kedungbanteng Village 3. Both villages have provided trash cans in each RT
	There is a buildup of garbage in the river	Severe damage or missing	
Health infrastructure	Hives, flu, diarrhea arise at the time of flooding	Slight damage	The existing potential of health infrastructure, namely: 1. There is already a community treatment center at the Village Health Post (Poskesdes)/village office and it was still active at the time of the flood 2. In the early 2020 floods, there were already mobile health services
Emergency operation post	The level of local communities involvement are relatively low based on the existing organizational structure of the field post	Slight damage	Flood disaster emergency operation posts in Kedungbanteng Village and Banjarasri Village formed by BPBD Sidoarjo Regency. The post organizational structure formed consists of various related agencies in governmental area
Community kitchen	1. The existing community kitchen are no longer operate by November 2020	None	There is a public kitchen outside the affected location (Kalidawir Village) involving relevant

Indicator	Actual conditions	Impact category	Potential
	2. There is no initiative of residents to form community kitchens independently		government agencies that actively distribute food to vulnerable groups (infants, elderly, pregnant women, etc.)
Shelter	1. Shelter capacity is insufficient to accommodate all potential affected people 2. Shelter are not equipped with adequate supporting facilities	None	The existing potential of shelter, namely: 1. Shelter is only available in Kedungbanteng Village (utilizing the village office) 2. In Banjarasri village there is no shelter, but some communities utilized a school and mosque for evacuation
Transportation	There is no alternative transportation vehicle during flooding	None	The existing potential of transportation, namely: 1. The main roads in both villages are in the process of being elevated, in order to be able to used in times of flooding 2. Residents of both villages have taken the initiative to hold parking for vehicle storage for residents whose houses were flooded 3. There are rubber boats facilities

The table above presents a comprehensive analysis of real-world situations observed during flood emergencies. This analysis is derived from a combination of in-depth interviews and observations, and it categorizes these findings into their relevant impact groups. This tabulation is used as the basis for the preparation of recommendations for flood risk reduction actions.

3.3.3 Recommendation for formulation

The following are the results of an analysis that results in action recommendations based on criteria or guidelines based on existing conditions in the field.

Table 6. List of alternatives formulated by the research team

Indicator	Impact category	Actions to follow up
Clean water and potable water	Severe damage or missing and None.	Clean water needs are calculated based on SNI 03-1733 of 2004 and Indonesian Government Regulation Number 14 of 2016 it is known that the standard of clean water supply in Kedungbanteng Village is 32,400 liter/day and Banjarasri is 15,780 liter/day. Meeting these needs can be done by maximizing the existing water reservoir system and maintaining consistency of water filling into the reservoir with the following scenarios: 1. Scenario 1: the addition of 8 water reservoirs in Kedungbanteng Village. 2. Scenario 2: Increase the frequency of water topping up to 3 times per day.
Sanitation	Moderate damage and Severe	To fulfill the need of sanitation in the emergency period, there are two scenarios developed, they are:

Indicator	Impact category	Actions to follow up
	damage or missing	1. Scenario 1: assuming 1 latrine for 12 households in accordance with SNI 03-1733 of 2004, it is necessary to add 43 portable public toilets. 2. Scenario 2: Improve existing toilets for better flood response (creation of shared sanitation using Tripikon-S technology).
Waste management	Severe damage or missing and None	Alternatives that can be applied in waste management during flood emergencies are: 1. Provides waterproof trash bins. 2. Periodic provision of garbage transport.
Health infrastructure	Slight damage	Based on SNI 03-1733 Year 2004, 1 community treatment center is needed for every 2,500 people, then the need for treatment centers in both villages is sufficient so that no additional intervention is needed.
Emergency operation post	Slight damage	Disaster management activities will be more effective if they involve the community as the subject of activities. This means that activities arise and are initiated by the community, BPBD simply monitors and facilitates activities.
Community kitchen	None	Alternatives to providing food during flood emergencies are carried out with the following efforts: 1. Public kitchens are formed by involving affected communities 2. The initiation of regular feeding for residents 3 times a day (routine)
Shelter	None	It is necessary to provide safe and comfortable evacuation (equipped with sanitation facilities, clean water, security, beds, places of worship, soup kitchens, etc.) referring to the standard shelter needs assuming the area requirement for temporary shelter is 3.5 m2 per person. With this standard, land is needed for temporary shelter covering an area of 3,780 m2 (Kedungbanteng) and 4,735.5 m2 (Banjarasri)
Transportation	None	Safe parking from flooding is provided for vehicle storage for residents affected by flooding

The solution given in the tabulation above is in the form of the number of emergency infrastructure provision needs to meet the needs of victims affected by floods in Kedungbanteng and Banjarasri Villages. These recommendations need to be confirmed to stakeholders to accommodate aspirations.

4 Confirming the actual infrastructures

4.1 Reporting the result of assessment

After formulating alternative solutions formed from a combination of potential and problems from the results of in-depth interviews with minimum standard needs from observations and calculations, it is necessary to report a list of alternative solutions simply. The report can be in the form of tabulations of alternative solutions containing information such as solution descriptions, quantification of the number/frequency of solution implementation, to indications of the location of solution implementation to provide a complete picture.

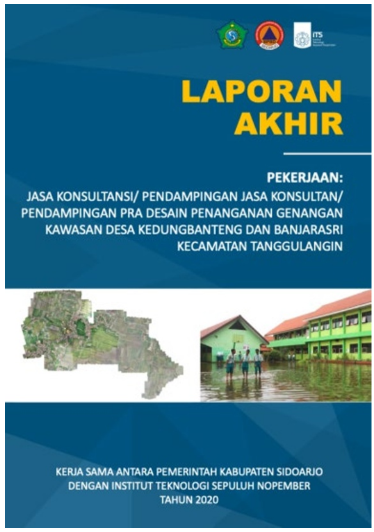

Fig. 3. Report the results of the study on the full assessment process

4.2 FGD to confirm the actual infrastructures

Alternative solution reports are then communicated to key stakeholders to verify and select alternative solutions that can be adopted through FGD activities. In this process, the results of identifying potentials, problems, and solutions processed by the team need to be corrected by stakeholders so that there is no misunderstanding of the problem so that the most appropriate solution can be formulated and selected.

4.3 Strategies to provide the actual infrastructures

The list of alternative solutions in section 4.2 should be planned related to the implementation time component, the subject in charge of implementation, to the source of funding by the team. The results of the formation of this plan can then be submitted to the competent authority in the implementation of the solution following its area of expertise.

5 Arranging rapid assessment model

Table 7. Comparison of the duration of existing model implementation and expected duration

No	Steps	Actual duration (days)	Expected duration (days)	Rationality for duration reduction
1	Finding Potential Infrastructures Needed	30	1	The process of finding a long list of infrastructures through literature review takes a long time. However, the results of this literature review can be a guideline that is used in other cases. Therefore, the literature review process can be replaced by utilizing study results from existing full assessment research.
2	Determining relevant emergency	30		The process of identifying disrupted and uninterrupted infrastructure in full assessment research uses the in-depth interview method. In the rapid assessment model, change on

	infrastructures for case study			methodology is proposed using a simple questionnaire with a checklist method.
3	Assessing relevant emergency infrastructures via in-depth interview	30	1	Identification of existing conditions of disrupted emergency infrastructure in the rapid assessment model is proposed to be simplified using checklist questionnaires.
4	Assessing relevant emergency infrastructures via observation			Identification of the existing condition of disturbed emergency infrastructure is also still carried out by the research team. The difference with the rapid assessment model is that observations are made using a more concise checklist questionnaire.
5	Recommendation Formulation	14		The recommendation formulation process conducted with a form which consolidate data from the previous form, comparing it with relevant indicators, and draw conclusions for follow-up activities.
6	Reporting the result of assessment	7	1	The long list of alternatives produced by the research team is then processed into one simple report as material reported to local governments. In the existing process, it takes 7 days because the report is formulated in the form of a complete report document so that there needs to be a modification of the document form into a simple tabulation so that it can be completed within 1 day.
7	FGD to confirm the actual infrastructure	30	1	The list of alternatives that have been prepared needs to be followed up to agree on a list of relevant solution activities to respond to flood conditions through FGDs. The realization of the implementation of this stage has a duration of 30 days for the confirmation process and an additional 7 days to map the person responsible per solution activity. This process is prolonged because the implementation is offline which is difficult to find a date agreement. With the teleconference media, obstacles from distance and time can be overcome so that this stage can be held for 1 day only.
8	Strategies to provide the actual infrastructures	7		
	Total days	**148**	**4**	

The process of carrying out a full assessment takes a very long time, which is 148 days, even though during an emergency, a quick assessment is needed to be able to deal with problems quickly to ensure residents can live a comfortable life during a flood emergency. It is undeniable that this full assessment process has a long duration because the development of assessment tools is carried out first, such as: (1) literature study for the type of emergency infrastructure; (2) creation of interview guidelines; and (3) the creation of observation guidelines. To accommodate the need for rapid provision during flood emergencies, a rapid assessment model is proposed which is a simplification of the assessment process and tools from the results of the full assessment study so that the needs assessment can be completed in just 4 days.

5.1 Finding potential infrastructures needed

By adopting full assessment output on literature study, the rapid assessment can bypass the need for an extensive literature review, relying instead on the established results as a reference point. Thereby, the here is the list of potential infrastructures needed that's shown in **Table 8.**

Table 8. Flood risk emergency infrastructures that are used in rapid assessment model

Long list of Flood Risk Emergency Infrastructures
Transportation
Clean Water and Potable Water
Flood Control Infrastructures
Drainage
Sanitation
Waste Management
Fire Protection
Green Open Space
Educational Infrastructures
Health Infrastructures
Public Service Infrastructures (Community Kitchen)
Commercial Facilities
Electricity
Telecommunication
Emergency Operation Post
Shelters

5.2 Determining relevant emergency infrastructures for case study

The revised method now employs a rapid assessment using a checklist method, expedited by stakeholders filling out the checklist, thereby enhancing efficiency and responsiveness in evaluating the research site's infrastructure challenges. **Table 9** shows on How the checklist method works and collect the data on the status of emergency infrastructures.

Table 9. Determining relevant emergency infrastructures in rapid assessment model

No.	Infrastructures	Disrupted	Operates Well
1.	Transportation	V	
2.	Clean Water and Potable Water	V	
3.	Flood Control Infrastructures	V	
4.	Drainage	V	
5.	Sanitation	V	
6.	Waste Management	V	
7.	Fire Protection		V
8.	Green Open Space		V
9.	Educational Infrastructures		V
10.	Health Infrastructures	V	
11.	Public Service Infrastructures (Community Kitchen)	V	
12.	Commercial Facilities		V
13.	Electricity		V
14.	Telecommunication		V
15.	Emergency Operation Post	V	
16.	Shelters	V	

5.3 Assessing relevant emergency infrastructures via in-depth interview

Rapid assessment model can significantly reduce implementation time by increasing survey personnel and adopting pre-developed questionnaires from the full assessment. **Tables 10** shows a checklist and filling the form methods to simplify the process**.** This adjustment not only accelerates the evaluation process but also ensures a more inclusive and participatory approach to identifying and addressing challenges in emergency infrastructures.

Table 10. Assessing relevant emergency infrastructures via in-depth interview in rapid assessment process

Infrastructures	Indicators	Minimum standard of service	Impact Category					Notes on potential shortage compared to the standards
			No Damage	Slight Damage	Moderate Damage	Severe Damage or Missing	Not Available	
Clean water and potable water	Clean water source				V			
	Clean water needs				V			
	Water quality				V			
	Water supply during floods				V			

5.4 Assessing relevant emergency infrastructures via observation

The method transitioned from a comprehensive assessment reliant on observations to a more rapid evaluation facilitated by the adoption of a checklist method. In this streamlined process, surveyors promptly fill out the checklist in a more efficient and responsive assessment of emergency infrastructures as shown in **Table 10**.

Table 10. Assessing relevant emergency infrastructures via observation in rapid assessment process

Infrastructures	Indicators	Minimum standard of service	Impact Category					Notes on potential shortage compared to the standards
			No Damage	Slight Damage	Moderate Damage	Severe Damage or Missing	Not Available	
Clean water and potable water	Clean water source					V		
	Clean water needs					V		
	Water quality					V		
	Water supply during floods					V		

5.5 Recommendation Formulation

The rapid assessment approach uses a structured form designed to streamline the process. This form plays a pivotal role as it consolidates data gathered from preceding forms, conducts a comparative analysis with relevant indicators, and synthesizes the information to draw conclusive insights for subsequent actions as it shows in **Table 12.**

Table 12. Recommendation formulation in rapid assessment model

Infrastructures	Standard Guidance	Minimum Standard	Current Condition*	Recommendation		
				Potential Strategy	Potential PIC	Potential Funding
Clean water and potable water	SNI 03-1733 of 2004 and Indonesian Government Regulation Number 14 of 2016	30 liter/person/day In total Kedungbanteng: 32,400 liter/day In total Banjarasri: 15,780 liter/day	There is no water source that works during floods other than reservoirs in each RT. From the existing reservoir capacity, RT 3 and 6 in Kedungbanteng Village have not been able to meet the clean water needs of their residents of 7,050 liters / day and 7,350 liters / day respectively	Provision of reservoirs with a capacity of 1800 liters as much as 3 water tanks each for Kedungbanteng Village RT 3 and RT 6.	Water Resources of Public Works Department	Government fund

*Current condition based on the results of assessment on relevant emergency infrastructures particularly on the column impacts and notes

The form comprises key categories, including infrastructures, standard guidance, minimum standard, current condition (based on the results of assessments, particularly focusing on impacts and notes), recommendation (potential strategy), potential person in charge (PIC), and potential funding. by incorporating these elements, the method ensures a comprehensive and organized framework, expediting the generation of alternative recommendations and fostering a more efficient decision-making process in emergency infrastructure planning and improvement initiatives.

5.6 Reporting the result of assessment

Table 13 shows the revised reporting method for rapid assessment model that involves the creation of a reporting form based on the outcomes of follow-up activities. This form provides key elements such as infrastructures, current condition (derived from assessment results), and recommendations (including potential strategy, potential PIC, and potential funding). This modification will not only speed up the reporting timeline but also ensures a concise and accessible presentation of critical information.

Table 13. Reporting the result of assessment in rapid assessment model

Infrastructures	Current Condition*	Recommendation		
		Potential Strategy	Potential PIC	Potential Funding
Clean water and potable water	There is no water source that works during floods other than reservoirs in each RT. From the existing reservoir capacity, RT 3 and 6 in Kedungbanteng Village have not been able to meet the clean water needs of their residents of 7,050 liters / day and 7,350 liters / day respectively	Provision of reservoirs with a capacity of 1800 liters as much as 4 each for Kedungbanteng Village RT 3 and RT 6.	Water Resources of Public Works Department	Government fund

*Current condition based on the results of assessment on relevant emergency infrastructures particularly on the column impacts and notes

5.7 FGD to confirm the actual infrastructures

The rapid assessment method can involves the creation of a structured form capturing the outcomes of FGD meetings, encompassing key elements such as recommendation (potential strategy, potential PIC, potential funding), approval (approved, approved with revision, rejected), and pertinent notes (**Table 14**). This adaptive approach not only accelerates the decision-making process but also overcomes logistical hurdles, ensuring a swift and effective response to flood conditions.

Table 14. FGD to confirm the actual infrastructures in rapid assessment model

Recommendation			**Approval**			**Notes**
Potential Strategy	Potential PIC	Potential Funding	Approved	Approved with Revision	Rejected	
Provision of reservoirs with a capacity of 1800 liters as much as 4 each for Kedungbanteng Village RT 3 and RT 6.	Water Resources of Public Works Department	Government fund		V		Due to limited funds, it is better that the number of reservoirs provided is 3 in each RT by increasing the frequency of filling to 3 times a day.

5.8 Strategies to provide the actual infrastructures

For rapid assessment, **Table 15** is meticulously designed to align with the recommendations, encapsulating crucial details such as potential strategy, potential PIC, potential funding, and the anticipated date of delivery. By streamlining this information into a comprehensive and structured format, the mapping of responsible parties becomes more efficient.

Table 15. Strategies to provide the actual infrastructures in rapid assessment model

Infrastructures	**Recommendation**			
	Potential Strategy	Potential PIC	Potential Funding	Date of Delivery
Clean water and potable water	Provision of reservoirs with a capacity of 1800 liters as much as 3 each for Kedungbanteng Village RT 3 and RT 6 with the frequency of water filling to 3 times a day.	Water Resources of Public Works Department	Government fund	Every day starting from March 12th, 2023

6 Conclusion

Assessing emergency infrastructures in responding to flood event should be carried out in an effective and timely manner. Current full assessment has reflected a long process (148 days) resulting ineffective to response on the emergency situation. Therefore, a rapid assessment is proposed that can fasten up the process into only four days of assessment.

To make a rapid assessment on emergency infrastructures after disaster events, a systematically process should be agreed among stakeholders. This paper proposed to have eight steps of rapid assessment namely (1) finding potential infrastructures needed; (2) determining relevant emergency infrastructures for case study; (3) assessing relevant emergency infrastructures via in-depth interview; (4) assessing relevant emergency infrastructures via observation; (5) recommendation formulation; (6) reporting the result of assessment; (7) FGD to confirm the actual infrastructure; and (8) strategies to provide the actual infrastructures, guided by the specific forms for relevant stakeholders. The forms can be advanced by using a google form to have a more efficient and effective ways of assessments. Within the every form, this paper proposes the key substance to direct the assessment process. Since the rapid assessment model relevant for the value of emergency, the rapid assessment can be adopted as the Indonesian standard in providing emergency infrastructure after a disaster event.

7 Acknowledgement

We would like to thank Institut Teknologi Sepuluh Nopember (ITS) for providing financial support through batch 2 departmental research funding with contract number 2391/PKS/ITS/2023.

References

[1] J. Rentschler, M. Salhab, and B. A. Jafino, “Flood exposure and poverty in 188 countries,” *Nat Commun*, vol. 13, no. 1, Dec. 2022, doi: 10.1038/s41467-022-30727-4.

[2] Center of Research on the Epidemiology of Disasters (CRED), “The Human Cost of Natural Disasters,” 2015.

[3] K. Schröter *et al.*, “Large-scale flood risk assessment and management: Prospects of a systems approach,” *Water Security*, vol. 14, Dec. 2021, doi: 10.1016/j.wasec.2021.100109.

[4] P. Wallemacq and R. House, “Economic losses, poverty & disasters: 1998-2017,” 2018. [Online]. Available: www.unisdr.org

[5] Data Informasi Bencana Indonesia (DIBI), “Profil bencana Indonesia,” 2022.

[6] G. Sofia, G. Roder, G. Dalla Fontana, and P. Tarolli, “Flood dynamics in urbanised landscapes: 100 years of climate and humans’ interaction,” *Sci Rep*, vol. 7, Jan. 2017, doi: 10.1038/srep40527.

[7] S. Hettiarachchi, C. Wasko, and A. Sharma, “Increase in flood risk resulting from climate change in a developed urban watershed - The role of storm temporal patterns,” *Hydrol Earth Syst Sci*, vol. 22, no. 3, pp. 2041–2056, Mar. 2018, doi: 10.5194/hess-22-2041-2018.

[8] M. Bermúdez, J. F. Farfán, P. Willems, and L. Cea, “Assessing the Effects of Climate Change on Compound Flooding in Coastal River Areas,” *Water Resour Res*, vol. 57, no. 10, Oct. 2021, doi: 10.1029/2020WR029321.

[9] S. A. H. B. S. Muzamil *et al.*, "Proposed Framework for the Flood Disaster Management Cycle in Malaysia," *Sustainability (Switzerland)*, vol. 14, no. 7, Apr. 2022, doi: 10.3390/su14074088.
[10] O. O. Omolara, S. A. Ablor, A. S. Adeola, O. Emefe, and L. O. Akanji, "Challenges of Substandard Drainage Systems and Effects of Flooding on the Sustainability of Inhabitants of Ogun State, Southwestern Nigeria," *Journal of Environmental Impact and Management Policy*, no. 35, pp. 7–24, Sep. 2023, doi: 10.55529/jeimp.35.7.24.
[11] G. Varlas *et al.*, "A multi-platform hydrometeorological analysis of the flash flood event of 15 November 2017 in Attica, Greece," *Remote Sens (Basel)*, vol. 11, no. 1, Jan. 2019, doi: 10.3390/rs11010045.
[12] M. Machado Toffolo, F. Grilli, C. Prandi, S. Goffredo, and M. Marini, "Extreme Flooding Events in Coastal Lagoons: Seawater Parameters and Rainfall over A Six-Year Period in the Mar Menor (SE Spain)," *J Mar Sci Eng*, vol. 10, no. 10, Oct. 2022, doi: 10.3390/jmse10101521.
[13] N. Hayati *et al.*, "Small baselines techniques of time series InSAR to monitor and predict land subsidence causing flood vulnerability in Sidoarjo, Indonesia," *Geomatics, Natural Hazards and Risk*, vol. 13, no. 1, pp. 2124–2150, 2022, doi: 10.1080/19475705.2022.2109518.
[14] A. Hadianti and B. G. Dewanto, "The simulation of urban development with the consideration of ground deformation threats in Sidoarjo Regency, East Java Province of Indonesia," *Remote Sens Appl*, vol. 32, p. 101019, Nov. 2023, doi: 10.1016/j.rsase.2023.101019.
[15] L. Resantie and E. B. Santoso, "Identifikasi pola perkembangan wilayah di Kabupaten Sidoarjo tahun 2009-2020," *Jurnal Teknik ITS*, vol. 10, 2021, doi: 10.12962/j23373539.v10i2.78928.
[16] Badan Pusat Statistik (BPS), "PDRB Atas Dasar Harga Konstan Menurut Lapangan Usaha (Juta Rupiah), 2017-2019," 2019. Accessed: Nov. 18, 2023. [Online]. Available: https://sidoarjokab.bps.go.id/indicator/52/49/2/pdrb-atas-dasar-harga-konstan-menurut-lapangan-usaha.html
[17] P. Setyaningrum, "Lumpur Lapindo: Penyebab, dampak, ganti rugi, hingga temuan 'harta karun' logam tanah jarang." Accessed: Nov. 18, 2023. [Online]. Available: https://surabaya.kompas.com/read/2022/01/26/205822478/lumpur-lapindo-penyebab-dampak-ganti-rugi-hingga-temuan-harta-karun-logam?page=all
[18] K. Ryanda, E. Y. Handoko, and P. Maulida, "Land Subsidence Study Using Geodetic GPS and GAMIT/GLOBK Software (Case Study : Banjarasri Village and Kedungbanteng Village, Tanggulangin District, Sidoarjo Regency)," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Dec. 2021. doi: 10.1088/1755-1315/936/1/012020.
[19] Lembaga Penyiaran Publik Lokal (LPPL) Radio Suara Sidoarjo, "Banjir tak surut sejak akhir 2020, warga Sidoarjo tidak ingin direlokasi," *2021*, Sidoarjo. Accessed: Nov. 18, 2023. [Online]. Available: https://www.facebook.com/radiosusi/photos/a.362934560978277/771436086794787/?type=3&paipv=0&eav=AfYU4wzUVKNq9bRAnQiVrFizfEbPoh7PADHKbaBBVv0QKLWLCsb21iknezx4GnHBaV8&_rdr
[20] Pemerintah Kabupaten Sidoarjo, Badan Penanggulangan Bencana Daerah (BPBD) Kabupaten Sidoarjo, and Institut Teknologi Sepuluh Nopember (ITS), "Laporan Akhir Swakelola Tipe II," 2020.
[21] A. Kotb, H. Elbardan, and H. Halabi, "Mapping of internal audit research: a post-Enron structured literature review," *Accounting, Auditing and Accountability Journal*, vol. 33, no. 8. Emerald Group Holdings Ltd., pp. 1969–1996, Nov. 04, 2020. doi: 10.1108/AAAJ-07-2018-3581.

[22] B. Carolyn Boyce, "Monitoring and Evaluation-2 CONDUCTING IN-DEPTH INTERVIEWS: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input," 2006.
[23] A. Bath, "In-depth Interviews: Definition and how to conduct them." Accessed: Nov. 22, 2023. [Online]. Available: https://www.questionpro.com/blog/in-depth-interviews/
[24] Columbia University Mailman School of Public Health, "Content Analysis."
[25] A. James, "Depth Interviews and Observation." Accessed: Nov. 22, 2023. [Online]. Available: https://www.e-education.psu.edu/ba850/node/686
[26] ODI, "Research tools: focus group discussion," 2009. Accessed: Nov. 22, 2023. [Online]. Available: https://odi.org/en/publications/research-tools-focus-group-discussion/
[27] KnowledgeBank, "Tools: Focus group discussion." Accessed: Nov. 22, 2023. [Online]. Available: knowledgebank.irri.org/capdev/images/stories/tools/Tools-Focus-group-discussion.pdf
[28] Pemerintah Republik Indonesia, "Peraturan Pemerintah (PP) Nomor 14 Tahun 2016 tentang Penyelenggaraan Perumahan dan Kawasan Permukiman," 2016.
[29] Direktorat Jenderal Cipta Karya Kementerian Pekerjaan Umum dan Perumahan Rakyat (PUPR), "Peran direktorat pengembangan kawasan permukiman dalam mewujudkan pembangunan infrastruktur yang layak huni dan berkelanjutan," 2019.
[30] M. A. E. Emanuelsson, N. Mcintyre, C. F. Hunt, R. Mawle, J. Kitson, and N. Voulvoulis, "Flood risk assessment for infrastructure networks," *J Flood Risk Manag*, vol. 7, no. 1, pp. 31–41, Mar. 2014, doi: 10.1111/jfr3.12028.
[31] B. Gersonius, R. Ashley, A. Pathirana, and C. Zevenbergen, "Climate change uncertainty: Building flexibility into water and flood risk infrastructure," *Clim Change*, vol. 116, no. 2, pp. 411–423, Jan. 2013, doi: 10.1007/s10584-012-0494-5.
[32] R. Espada, A. Apan, and K. Mcdougall, "Using spatial modelling to develop flood risk and climate adaptation capacity metrics for vulnerability assessments of urban community and critical water supply infrastructure," 2013.
[33] A. Fekete, K. Tzavella, and R. Baumhauer, "Spatial exposure aspects contributing to vulnerability and resilience assessments of urban critical infrastructure in a flood and blackout context," *Natural Hazards*, vol. 86, pp. 151–176, Mar. 2017, doi: 10.1007/s11069-016-2720-3.
[34] D. P. Wijayanti, M. J. Rahayu, and R. P. Utomo, "Ketercapaian perwujudan lingkungan permukiman layak huni dalam rangka Program Penataan Lingkungan Permukiman Berbasis Komunitas (PLPBK) di Kabupaten Karanganyar," 2016.
[35] Badan Standardisasi Nasional (BSN), "Standar Nasional Indonesia (SNI) 03-1733-2004 tentang tata cara perencanaan lingkungan perumahan di perkotaan," 2004.
[36] Pemerintah Republik Indonesia, "Peraturan Pemerintah (PP) Nomor 50 Tahun 2011 tentang Rencana Induk Pembangunan Kepariwisataan Nasional Tahun 2010-2025," 2011.
[37] S. Thacker, S. Kelly, R. Pant, and J. W. Hall, "Evaluating the Benefits of Adaptation of Critical Infrastructures to Hydrometeorological Risks," *Risk Analysis*, vol. 38, no. 1, pp. 134–150, Jan. 2018, doi: 10.1111/risa.12839.
[38] Badan Nasional Penanggulangan Bencana (BNPB), "Peraturan Kepala (Perka) Badan Nasional Penanggulangan Bencana (BNPB) Nomor 3 Tahun 2016 tentang Sistem Komando Penanganan Darurat Bencana," 2016. [Online]. Available: www.peraturan.go.id