Ocean and Coastal Management 163 (2018) 445–455

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Adaptation to coastal flooding and inundation: Mitigations and migration pattern in Semarang City, Indonesia

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ARTICLE INFO

Keywords:
Flooding
Inundation
Rob
Mitigation
Community adaptation
Migration
GIS

ABSTRACT

As a global issue, climate change has been significantly influencing coastal areas and causing changes in marine and terrestrial environments. The increase in sea-level rise (SLR), for example, has worsened the quality of life of coastal communities, and this risk increases especially in coastal cities of the developing world. This paper aims to comprehend the variety of self-mitigations and the patterns of local migrations of communities in the northern part of Semarang City, Indonesia. The delineation of the risk areas for *Rob*, a local term for inundation and flooding caused by sea water overflow, was accomplished with the application of GIS. Interviews with the inhabitants were conducted to investigate the scale and frequency of *Rob* and the variety of mitigation, adaptation, and responses at the individual, household or community level. Further investigation was done to comprehend the reasons why people moved away from their current residence to their intended locations. The results show that most inhabitants prefer to stay and to adapt rather than to leave, due to social factors such as being comfortable with their community relationships. Those who wanted to move chose diverse locations spread across various areas of the city. Safer places in the hilly areas of southern Semarang and other residences close to their family or relatives were the most preferable. Based on this understanding, local government should encourage people to be more aware of the potential hydro-meteorological hazards threatening their environment.

1. Introduction

Influenced by marine and terrestrial environments, coastal areas are extremely vulnerable to climate change (Hansen, 2010), the impacts of which trigger sea-level rise (SLR). According to the Special Report on Emissions Scenarios of the Intergovernmental Panel on Climate Change (IPCC), the global mean sea-level is estimated to rise 22–34 cm between 1990 and the 2080s (McGranahan et al., 2007). SLR has caused coastal inundations in many locations around the world, causing many residents to live in discomfort. Its danger is usually measured by a set of parameters, such as the depth of water, duration, and velocity (Marfai and King, 2008a). This situation, in turn, induces major risks to coastal regions and the people. Approximately 600 million people and 2/3 of cities in the world are located in such areas (McGranahan et al., 2007).

About 23% of the world's population (around 1.2 billion people) live within 100 km of the coast and this figure is estimated to reach 50% in 2030 (Adger et al., 2012). This situation will increase the risk of the population affected by coastal inundation and other types of hydro-meteorological hazards, such as typhoons, hurricanes, sheet flooding, and coastal and river-based floods (Kötter, 2003).

In dealing with hydro-meteorological hazards, the communities make efforts to adapt in many ways, which may start with lower-effort measures then shift to higher-effort and more costly measures (Koerth et al., 2013a, b). When the hazards' pressure gets bigger, migration can be an option to overcome the problem (Black et al., 2011; Nawrotzki and DeWaard 2018). The decision to migrate can be influenced by the desire to earn economic opportunities, income recovery, climate amenities (Klaiber, 2014; Penning-Rowsell et al., 2013), and even personal history (Koerth et al., 2013a, b). The destination of migration is often considered by proximity to the workplace (Lu et al., 2018). For this reason, institutional mechanism and social network are essential to be regarded (Scheffran et al., 2012). The cases in South American countries, for examples, show that they have determined policies to address human mobility in the context of disasters and climate change

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https://doi.org/10.1016/j.ocecoaman.2018.07.017
Received 29 November 2017; Received in revised form 2 July 2018; Accepted 18 July 2018

(Yamamoto et al., 2017).

Located in tropical climate areas, Indonesia often faces extreme weather, including temperature and wind (Løvholt et al., 2014; Buchori and Tanjung, 2014; Buchori et al., 2018). Such climatic conditions, along with time, the growth in human activities, and environmental degradation, tend to become worse and lead to an increasing number and intensity of hydro-meteorological disasters. This country, covering about 88,000 km coastline and more than 17,500 islands, is highly vulnerable to the impacts of SLR (Sejati and Buchori, 2010; Maulana and Buchori, 2016; Marfai and King, 2008b; Marfai and King, 2007; Marfai et al., 2008a, b, c; Marfai et al., 2008; Firman et al., 2011; Marfai and King, 2008a; Buchori et al., 2018).

Semarang is a large developing coastal city in Indonesia, centred in the northern coastal and low-lying areas, and situated at an elevation of between five and ten metres above sea level. There are 20 villages in the coastal zone and its neighbour prone to coastal hazards (Marfai and King, 2008a). The rate of sedimentation along Semarang coast varies from 8 to 15 m per year, while the height of inundation in the coastal and low lying area reaches about 40–60 cm from the ground (Marfai and King, 2008a). This tendency leads to urbanisation and environmental problems, such as coastal erosion and sedimentation, over-exploitation of ground water resources, land subsidence, tidal inundation, and *Rob*, a local term for flood and inundation caused by sea water overflow. The term, *Rob*, is used because it is unique, in the sense that it mainly occurs in the northern coastal region of Java. Specifically, *Rob* refers to “inundation” that is mostly permanent and “flooding” that is temporary. Overall, this situation will increase the risk of flooding and other kinds of environmental damage in the coastal areas (Ardiansyah and Buchori, 2014; Susi et al., 2017; Buchori et al., 2013; Sejati and Buchori, 2010; Maulana and Buchori, 2016).

The *Rob* in Semarang significantly influences the community life (Marfai et al., 2008a, b, c; Buchori et al., 2018), and it has the potential to degrade many public activities. Previous studies have shown that the impacted people tend to adapt to the problem (Damen and Sutanta, 2003; Sejati and Buchori, 2010; Khadiyanto et al., 2017), with some of them tend to move to safer places elsewhere in the city.

Therefore, this study aims to observe various kinds of community adaptation, formed as structural and non-structural self-mitigations, and the willingness to move, including the locations and reasons for their decision. It is a continuation of the previous study of Buchori et al. (2018), revealing that the potential risks affected by hydro-meteorological hazards have improperly accommodated in the City Spatial Plan. The results of this study are expected to enrich our understanding in dealing with *Rob* and be beneficial for the local government to evaluate the City Spatial Plan, which has less concern on the issues of hydro-meteorological hazards. Moreover, the approach of this study can be replicated to other locations with comparable characteristics.

Following this introduction about the reasons why this study was essential, the next section is literature review on the previous studies about disaster mitigations and local migrations. Then, in the method section, how the data were gathered and analysed is explained. The next part is the analysis and discussion elaborating the fact findings and the knowledge from the observed literature. The final section concludes and gives the implications to the corresponding body of knowledge and recommendations to local government.

2. Disaster mitigations and local migrations

2.1. Disaster mitigations

The International Emergency Disaster Database (EM-DAT) defines a disaster as an event which enforces the local population to request external assistance at the national or international level, or whatever is acknowledged by multilateral agencies, or at least two sources, such as national, regional or international aid groups, and the media (Daramola et al., 2016). The ability to cope and recover from disasters with the minimum impact and damage is acknowledged as resilience (Cutter et al., 2008). The concept of resilience was first used by ecologists to illustrate the system's ability to assimilate change and disturbance, and retain critical functions within the particular domain (Holling, 1973). Regarding disaster, resilience is also recognised as the capacity of a community to withstand or adapt to a hazardous condition, and to establish acceptable functions and structures (Hung et al., 2016).

Resilience to disasters is vital for a community to enhance its ability to plan, absorb, and recover from adverse events in a timely and efficient manner. Lack of planning, land management and preparedness will increase the potential vulnerability of a community to a hazardous condition. Thus, taking decisive action by creating an effective disaster management system at the national and local levels is essential, particularly to produce a platform to ensure the community becomes resilient (Joerin et al., 2012; Cutter et al., 2014; Kötter, 2003).

As far as addressing a disaster is concerned, the community resilience should better start with mitigation, which relates to pre-activities that can eliminate or reduce the impact of the disaster (Montoya, 2003). Mitigation is used as a measure to predict, prevent, and respond to disasters (Keeney, 2004), and can affect the level of adaptation, although in the short term it has a small effect (Farber, 2007). However, it is crucial to suppress the impact of disaster losses, including from hydro-meteorological hazards.

One mitigation measure implemented before a disaster strikes is an early warning system, which can detect future disasters, provide information to people who are at risk, and review factors which endanger the decision-making and action process (Sorensen, 2000). Meanwhile, the form of mitigation performed while a disaster is in progress is an evacuation system. Evacuation will be effective if people and goods can be moved to safer areas within an acceptable timeframe (Chien and Korikanthimath 2007). However, effective evacuation is not easy, especially in developing countries that often face a lack of communication and public transportation. Nevertheless, it is still possible with sufficient preparation, not only by communities but also government institutions responsible for disaster management. A warning system and evacuation plan are therefore critical when dealing with a large-scale disaster, especially to prevent loss of life (Fuchs, 2010).

Mitigation strategies can be structural and non-structural (Saravanan, 2016; Thampapillai and Musgrave, 1985; Hunter, 2005; Poussin et al., 2012; Dawson et al., 2011; Kundzewicz, 2002; Marfai et al., 2008a, b, c; Kötter, 2003). Structural mitigation focuses on physical constructions to reduce or avoid possible hazard impacts. In cases of flood hazards, the traditional approach of structural flood mitigation relies on physical buildings like dams, dykes, and channel improvements (Kötter, 2003). Besides, it can also be formed as physical improvements or modifications of the building, such as elevating the house floor and building a second story house. Moreover, non-structural mitigation emphasises knowledge, public awareness raising, training, and education, along with practice or agreements, especially in policy and law (UNISDR, 2009). With flood hazards, non-structural measures include flood warnings, evacuation, floodplain land use management, flood checks, and flood insurance (Thampapillai and Musgrave, 1985). Although the two approaches are different, both types of mitigation have equally important roles, which may be best applied in combination (Johnston et al., 2014).

Coastal cities need particular attention related to community awareness and resilience towards hydro-meteorological hazards, especially in climate change cases. Adapting to climate change is, therefore, an essential part of ensuring that communities can live and work in the desirable places. Essential lessons outlined by several researchers on the climate adaptation in coastal area development are useful. They are able to improve our understanding on many aspects, such as its impacts (Parker, 2014; Hansen, 2010), risk and vulnerability assessment (Faustino and Sales, 2009; Gibbs, 2015; Johnston et al., 2014), management planning and sustainable adaptation (Hurlimann et al., 2014; Bi et al., 2013), and mitigation planning (Imaduddina and Subagyo, 2014; Hakim et al., 2017).

2.2. Local migration

Migration flows impacted by natural disasters are often categorised as “distress migrations” or “forced migrations” (Raleigh et al., 2008; Raleigh, 2011). The characteristics of disaster-induced migration vary, depending on location, the type and severity of the disaster, vulnerability level, community capacity to respond and adapt, evacuation opportunities, donated aid, and local government support through relevant regulations (Raleigh et al., 2008). Some aspects affecting the community response in facing disasters are opportunities to obtain compensation, the extent of community support for relocation and resettlement programmes, and the possibility of recovery and improvement of income (Turton, 2003).

The decision to migrate is a response to the stress experienced by the inhabitants of specific residential locations, including dissatisfaction with environmental facilities caused by pollution, congestion, and crime. In such cases, community stress leads to a willingness to find alternative housing locations (Hunter, 2005). The potential migrants determine alternative residential locations based on their anticipated satisfaction with the preferred locations.

If the total benefits of migration are more significant than the total costs, people prefer to migrate (Reuveny, 2007). Migration as the preferred response of a community to SLR depends on the capacity of the community and the government to reduce the disaster risks. There are several options for the government, such as improving infrastructure for security, land use modification, the use of construction technology, and special handling of vulnerable areas. Unfortunately, the major migrant destinations are the areas being most at risk, because they offer better economic opportunities, such as proximity to industry and services (Tacoli, 2009).

Mitigation of flood risk can be achieved by managing the hazard conditions, to reduce the exposure and vulnerability of the communities, and simultaneously build the capacity to adapt. In this case, the development of strategies for flood mitigation requires a collective effort by the communities, institutions, and organisations concerned in helping to secure property and especially human security (Ntajal et al., 2016).

Disasters may occur suddenly (a quick onset) or gradually (a slow onset). Different measures for disasters will affect migration movement differently. Climate related disasters, such as the phenomenon of SLR, droughts, and land subsidence, are included in the slow-onset category, which can be compared to a disease, or a “chronic” phenomenon. In contrast, hurricanes, typhoons, tsunami, and earthquakes are “acute” phenomena. In many cases, the rate of migration movement is strongly influenced by economic conditions. In the case of a slow and long-term (chronic) disaster, vulnerable individuals would tend to survive and have no desire to move (Tacoli, 2009).

Individuals' decisions to migrate are significantly influenced by sudden and short-term environmental events (Koubi et al., 2016). Slow environmental changes have smaller immediate impacts on individuals' lives. For this reason, people tend to adapt to the environment rather than to migrate, and they also tend to have strong social and economic bonds with their residential locations. There are several actions they can take: carry on and do nothing; stay there and try to do something to reduce the problem; or leave the affected area by migrating to a safer place (Reuveny, 2007).

3. Method

This study is a quantitative one, in which data and information were mainly gathered from field observations, using popular techniques such as questionnaires, interviews, and documentary reviews (Neuman, 2014). The questionnaire technique was performed by questioning individuals and then compiling, describing, and discussing their responses (Jackson, 2011). This study has completed the following stages:

- Preparation of the spatial vulnerability map of Semarang coastal areas, divided into two zones, i.e., the projected areas of permanent and temporary *Rob* for 2031. This delineation is based on the previous research in 2016 (Buchori et al., 2018). The projection is based on a contour map from 2000, validated in 2016. The year 2031 is chosen based on the planning period of the City Spatial Plan (*Rencana Tata Ruang Wilayah Kota*) of Semarang, that is, 2011–2031.
- Identification of the mitigation strategies of structural and non-structural measures in the coastal areas of Semarang. In this regard, the community's experience with a range of measures was identified. The data was based on the questionnaires distributed to the community living in each *Rob* zone. There were two types of population (K = 2), that is, the households living in the temporary *Rob* areas (N1) and those in the permanent *Rob* areas (N2). N1 and N2 were accounted for 23,480 and 13,540, respectively, adjusted based on the Statistic Office's data in 2017 and the map of buildings of Semarang City. According to Slovin's formula (Tejada and Punzalan, 2012), which n = N/1 + Ne2, and using e = 0.1, both categories of samples (n1 and n2) were accounted for 100 each. Extended about 10%, the sample sizes were finally 110 households for each category. The questionnaires were randomly distributed along the study areas. After the error samples were removed, the final respondents were 108 and 107. The area's delineation and the distribution of respondents are shown in Fig. 1.
- Identification of the community's willingness to move to other safer areas and observation of the reasons why for moving or not.
- Comparison of the data with the questionnaire results. This information was then used to explain the migration pattern of the people living in the *Rob* prone areas of coastal Semarang. In this analysis, the map of migration pattern was generated using GIS tools.

4. Analyses and results

This part consists of identification of mitigation and migration patterns, collation of information on the spatial variability of people's awareness, and capture of the drivers behind the people decisions to stay or relocate.

4.1. Characteristics of respondents

Fig. 2 represents the typical characteristics of the respondents. Their ages were diverse, ranging from 21 to 83 years old. Many of the respondents were female and housewives, the economic situation of those living in the 2031 projected areas of temporary Rob was better than those in the permanent Rob. As shown in Table 1, many respondents (80%) had a motorcycle for their daily transportation. A few (4%) had a bicycle, car or other vehicles (4% each, respectively). The remaining 11% of the respondents had no vehicle. The respondents generally lived in a narrow building within an area of 75m2 or less. The land status of 84%, 10%, and 6% of the respondents was property rights, owned by another party, and leased, respectively.

4.2. Rob situation in the study area

The survey was conducted during the dry season in 2017. Comparing to the situation in 2016 (Buchori et al., 2018), it was found that some locations projected to be in permanent *Rob* in 2031 had been spared. The expected reason for this was that the infrastructure improvement by the local government can be considered as a kind of structural mitigation effort. However, the *Rob* was more severe than before in Tanjung Mas and Bandarharjo Urban Villages (*Kelurahan*) of

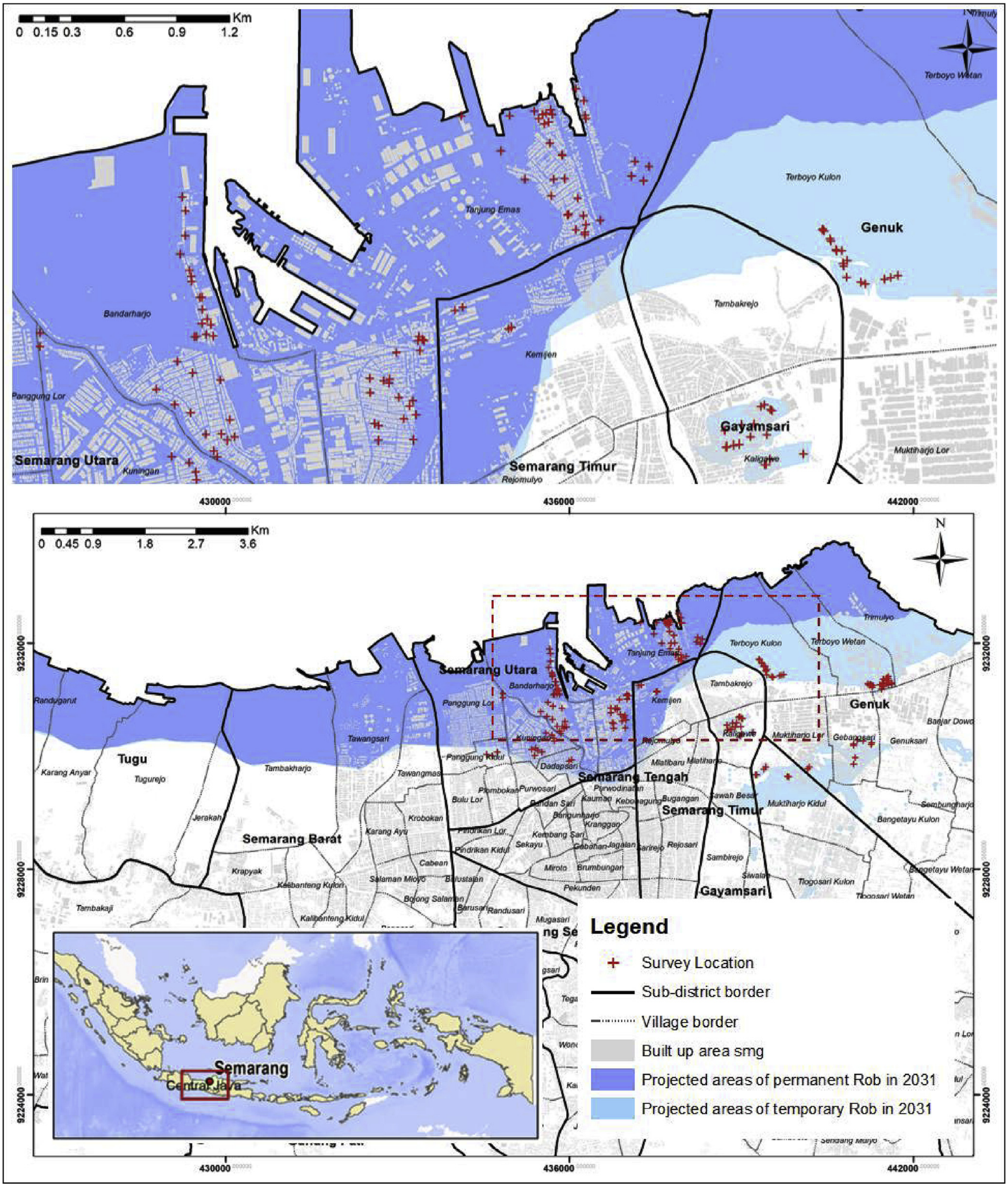

Fig. 1. Distribution of respondents.

Semarang Utara Sub District (*Kecamatan*). According to the respondents' opinion, this situation was affected by the unintegrated development of an embankment by the local government. Moreover, the construction of a river dam on the northern side of Tanjung Mas Village had produced excessive wastewater frequently flowing to the southern part of the village, especially during the rainy season. Overall, the situation in the projected areas of permanent *Rob* was worse than that in the projected areas of temporary *Rob*, as seen in Table 2.

Table 3 shows the *Rob* intensity in both 2031 projected areas of temporary and permanent *Rob*. The facts show that the daily *Rob* intensity was just found in the projected areas of permanent *Rob*. However, it is interesting that the number of respondents free from *Rob* and

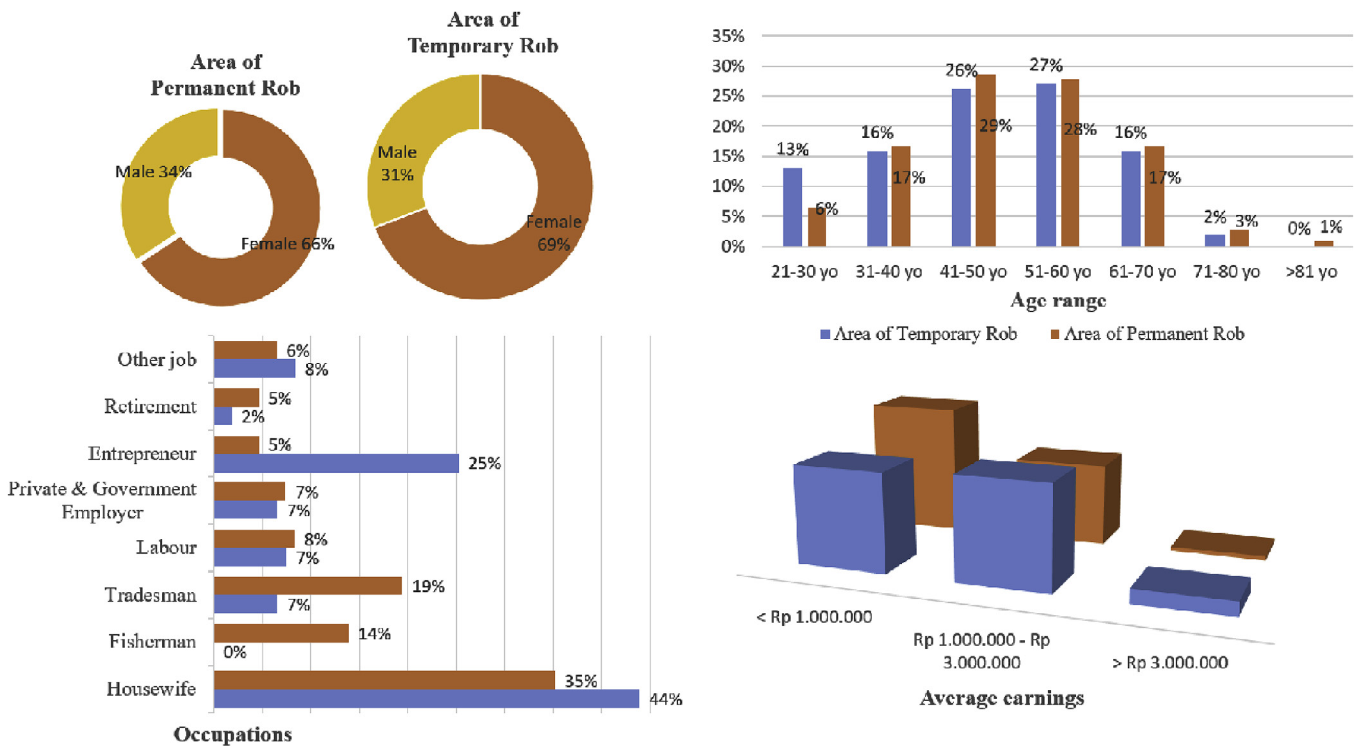

Fig. 2. Typical characteristics of the respondents.

Table 1
Socio-economic situation of the respondents.
Source: Primary Survey, 2017

The Ownership of Transportation Mode	Projected Area of Temporary *Rob* for 2031	Projected Area of Permanent *Rob* for 2031	Total Projected Area of *Rob* for 2031	
None	13	11	24	11%
Motorbike	69	61	130	60%
Bicycle	3	6	9	4%
Motorbike & Bicycle	14	30	44	20%
Car & Other Vehicles	8	0	8	4%
Land Ownership				100%
Property Rights	86	95	181	84%
Leases	8	5	13	6%
Usage Rights/Others	13	8	21	10%
Building Size (m2)				100%
< 75 m2	68	77	145	67%
75–100 m2	18	14	32	15%
100–125 m2	11	9	20	9%
> 125 m2	10	8	18	8%
				100%

Table 2
Current severity of *Rob* in the projected areas.
Source: Primary Survey, 2017

The severity of *Rob*	Projected Areas of Temporary *Rob* for 2031		Projected Areas of Permanent *Rob* for 2031		Total Projected Areas of *Rob* for 2031	
Rob in the entire house	13	12%	34	31%	47	22%
Rob in some part of the house, mostly the outside	36	34%	46	43%	82	38%
Rob in the street but never reaching the house	58	54%	28	26%	86	40%

seasonal *Rob* in the projected areas of permanent *Rob* was higher (27% and 15%) than that in the projected areas of temporary *Rob* (6% and 10%). The respondents believed that this situation was triggered by the change in the level of river sedimentation and the increase of clogging in the drainage system in the projected areas of temporary *Rob* on the one hand, and the improvement of local infrastructure in the projected areas of *Rob* on the other. Those areas were relatively safe from *Rob* in the dry season, but whenever the rainy season came the threat of *Rob* was still a massive issue.

The study area is generally located on low elevation sites. Some respondents even live in the land below the sea level, which is certainly uncomfortable. Land subsidence, worsened by the poor waste management system, seems to be the main reason for this. Drainage channels are often clogged by unmanaged solid waste (Fig. 3), and the river in the area also experienced severe sedimentation.

Responding to this situation, many respondents (60%) had worked together to clean the environment, including ditches and streets. However, others admitted to be passive and had not made any effort. This fact shows that the people's awareness of preventing Rob was relatively low.

4.3. Community adaptation

The residents had made various efforts to avoid and adapt to *Rob*. For example, 52% of the respondents had elevated their houses (Table 4), with the additional heights vary between 50 and 400 cm (Fig. 4). Other respondents (31%) simply moved their goods to safer places whenever *Rob* occurred, without making any structural effort to adapt. The remaining 17% of the respondents had both improved their houses and evacuated their goods. Table 4 also shows that the residents who would be living in the projected areas of permanent *Rob* in 2031 would prefer to raise their houses than to take any other measure. On the other hand, those who would be living in the projected areas of temporary *Rob* in 2031 tended to choose to move their belongings to safer places when *Rob* came.

Meanwhile, the local government had undertaken various

Table 3
Rob intensity.
Source: Primary Survey, 2017

Rob Intensity	Projected Areas of Temporary *Rob* for 2031		Projected Areas of Permanent *Rob* for 2031		Total Projected Areas of *Rob* for 2031	
Everyday	0	0%	39	36%	39	18%
Weekly (several times a month)	71	66%	24	22%	95	44%
Annually (several times a year)	19	18%	0	0%	19	9%
Seasonal (only in the rainy season)	11	10%	16	15%	27	13%
Free from *Rob*	[a]6	6%	[b]29	27%	35	16%
		100%		100%		100%

Notes.
[a] Coastal inundation never occurred.
[b] Safe from coastal inundation for more than 2 years.

infrastructure constructions, such as elevating the road level, creating dykes, and installing pumping systems around the affected areas. Table 5 shows that as many as 94% of the respondents living in the projected areas of permanent *Rob* stated that the government had made adequate efforts with structural mitigation to overcome the *Rob*. However, half of them felt that specific non-structural mitigation had not been conducted, while the other half stated that the local government had already given *Rob*-related education and informed people of the importance of green belt (mangrove) planting. Conversely, many respondents living in the projected areas of permanent *Rob* stated that the local government had not made any effort in structural (95%) and non-structural (89%) mitigations.

Overall, half of the respondents stated that they were satisfied with the local government efforts with structural mitigations, but only 31% of them confirmed that they were satisfied with the efforts of the local government for non-structural mitigations.

Structural mitigation by the local government surely helped many people to reduce the negative impacts of *Rob*. However, it might force the community to make additional effort to adapt. For example, they might have to elevate their houses to follow the raise of the road level; otherwise, their houses' elevation would have been lower than that of the road, and the *Rob* would inundate the properties more badly (Fig. 5). For a while, the government's solution was effective, but whenever the rainy season arrived, the situation was worse for those who could not elevate their houses.

4.4. Preference to stay or leave

Table 6 shows that the majority of the respondents (81%) preferred to stay rather than to migrate (19%). The reasons were mainly based on their emotional attachment to their places of living (41%) and the proximity to the working places (34%). The other reasons were: the value of their inherited properties (10%); the proximity to public facilities (7%); the inability to migrate (4%); and, the desire to live close to families or relatives (4%).

Table 4
Self-structural mitigation.
Source: Primary Survey, 2017

Structural Mitigation	Projected Areas of Temporary *Rob* for 2031		Projected Areas of Permanent *Rob* for 2031		Total Projected Areas of *Rob* for 2031	
Elevated their house	26	24%	85	79%	111	52%
Move things to a safer place	66	62%	1	1%	67	31%
Both of the above	15	14%	22	20%	37	17%
	107	100%	108	100%	215	100%

The respondents who preferred to migrate did so mainly because of a desire to seek a safer area (54%) and of being able to live close to families or relatives (22%). However, there were other reasons such as the intention to seek a better quality of life (12%) and the desire to move back to their home town (7%). Also, the need to find cheaper land (2%) and the desire to avoid extra costs by elevating their houses (2%) were among the reasons.

The fact that many respondents preferred to stay implies that people were aware of the consequences of living in the *Rob* prone areas. It suggests that they had prepared both mentally and financially for the survival mechanisms. Whenever seawater begins to rise, they prepare to move their belongings to safer places. They also save extra money to elevate their houses or raise the floors in the future.

Fig. 3. Low elevation site and poor solid waste management.

Fig. 4. Elevated houses.

Table 5
Public opinions on the structural and non-structural efforts by the local government.
Source: Primary Survey, 2017

Structural Mitigation	Projected Area of Temporary *Rob* for 2031		Projected Area of Permanent *Rob* for 2031		Total Projected Areas of *Rob* for 2031	
Structural Mitigation:						
Satisfactory Effort	5	5%	102	94%	107	50%
Lack of Effort	102	95%	6	6%	108	50%
Total	107	100%	108	100%	215	100%
Non-Structural Mitigation:						
Satisfactory Effort	12	11%	54	50%	66	31%
Lack of Effort	95	89%	54	50%	149	70%
Total	107	100%	108		215	100%

4.5. The pattern of local migration

The physical and emotional aspects are the basis of comfortable living criteria. The survey results show that phycological and emotional aspects dominated the decision to stay or to move out. Although it seems illogical when people choose to stay in an uncomfortable *Rob* location, this reveals that they preferred to stay because of their emotional attachment to their home. A small number of respondents wanted to move because they felt the situation was no longer bearable. They needed a more comfortable place for a better living. Based on the interview, the primary consideration for choosing a new location to live in was that it should be safer from *Rob*. Also, the factor of proximity to families or relatives was an essential consideration.

Among the respondents who intended to move, a significant number of them (44%) selected a location in the southern part of Semarang, which is dominated by hilly areas. Banyumanik, Tembalang, Gunungpati, and Mijen Sub-Districts were the most desirable destinations. Some (22%) chose to move to the eastern part of Semarang, considering that it was not so far from their original places of living. In this case, the preferred locations were in the Sub-Districts of Genuk, Pedurungan, and Semarang Timur. The rest of the respondents wished to move to the western part (10%), centre (7%), or to remain in the northern part of Semarang (2%).

Few respondents (15%) wanted to move out of Semarang City and chose to return to their home villages in the neighbouring regions, that is, Demak, Ungaran, and Kendal. Besides, a small percentage of the respondents intended to move to their hometowns in other areas located away from Semarang. Fig. 6 presents a migration diagram of the origins and preferred destinations of the *Rob*-affected people living in the Semarang coastal area.

5. Discussion

The kinds of adaptation chosen by the community in the coastal area of Semarang were quite various. Generally, they preferred to stay and adapt according to their ability, rather than choosing to leave. Those who intended to leave preferred to select safer places located in the southern part of Semarang. As shown in Fig. 6, proximity to workplaces and facilities was less considered. This finding is quite different with that of Tacoli (2009) stating that people tend to move to areas that are also prone to disaster because of the proximity to workplaces and facilities.

Respondents who chose to stay or leave had distinct reasons. Various driving factors influenced the decision of 19% of the respondents to leave, with as many as 54% of them perceiving that their

Fig. 5. Sinking houses affected by the increased street level.

current living environments were unaffordable and uncomfortable. They intended to move away from places affected by *Rob* to find a better living environment. Following Hunter's (2005) opinion, this discomfort situation caused people stress and forced them to migrate.

Many respondents (81%) said that they wanted to stay despite the uncomfortable environment because of their emotional bond to their current place (49%) or their intention to maintain their inherited land (10%). Few of them (4%) had no economic ability. Other factors such as a more strategic location close to a workplace (34%) as well as proximity to public facilities and downtown (7%) were also considered. The consideration for choosing this strategic location is in accordance with Tacoli's (2009) findings.

The desire to move can be separated into two groups, namely, voluntarism and compulsion. In this study, compulsion was more dominant as can be seen from the reasons for moving, that is, looking for a place to live that was free of *Rob*, looking for a better life, and avoiding the additional costs due to Rob. Voluntary reasons, such as wanting to return home or being close to relatives occupied only a small proportion.

The *Rob* phenomenon in Semarang can be categorised as a chronic phenomenon, a disaster tending to last for a long time with slow escalation and predictable severity. In such situation, people tend to be more adaptive to their environment (Koubi et al., 2016). Although uncomfortable, they chose to stay and adapt instead of moving to other locations.

Responding to the *Rob* that had caused upheaval within the community, the local government had made several attempts to improve the urban infrastructure. Roads damaged by *Rob* had been routinely repaired and elevated. The normalisation of the rivers was also encouraged in many places. The widening of the river, the construction of embankments, and the installation of pumps to transfer the *Rob* water from the city to the sea had also been carried out at specific prone zones. These efforts helped overcome *Rob*, temporarily, but had not solved the entire problem.

In the long term, continuously elevating and repairing the roads will be detrimental to the local government because the sea water still rises

Table 6
Preference and motivation to stay and/or migrate.
Source: Primary Survey, 2017

Preferences	Motivation	Projected Area of Temporary *Rob* for 2031 (%)	Projected Area of Permanent *Rob* for 2031 (%)	Total Projected Areas of *Rob* for 2031
Stay	Proximity to work place	50%	19%	34%
	Proximity to public facilities	14%	0%	7%
	Inability to migrate	0%	8%	4%
	Emotional attachment to the place	13%	68%	41%
	Value of inheritance property	18%	2%	10%
	Proximity to family or relatives	5%	3%	4%
Total		100%	100%	100% (81%)
Migrate	Seeking a safer area (no rob)	74%	28%	54%
	Seeking a better quality of life	0%	28%	12%
	Cheaper land	4%	0%	2%
	Proximity to family or relatives	17%	28%	22%
	Avoiding extra cost of elevating the house	4%	0%	2%
	Return to the home town	0%	17%	7%
Total		100%	100%	100% (19%)

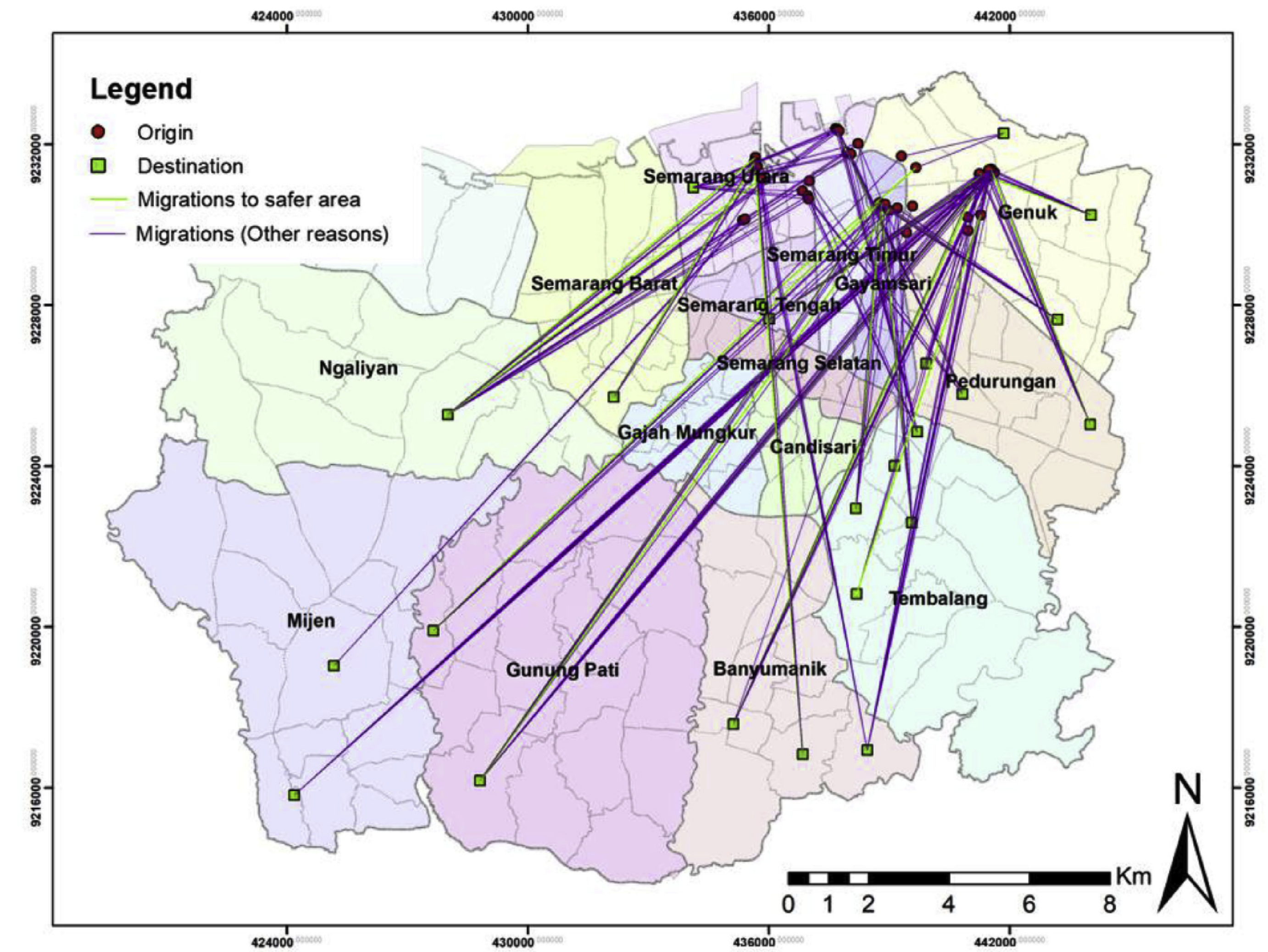

Fig. 6. The migration pattern: origin and destination.

due to, most probably, the global warming and land subsidence. If the local government only focuses on such short-term measures without complementing them with long-term oriented measures, the budget will be costly ineffective. This situation can inhibit the city's development. The construction of dykes and the installation of pumps are no exception. If sea water level continues to rise, pumping water will not be a permanent solution. For this reason, the local government should develop innovative measures. Strengthening the role of the Spatial Plan of Semarang City may be one such solution. It is especially so when knowing that previous studies have shown that the issue of hydrometeorological hazards has still not been widely considered (Sejati and Buchori, 2010; Riki and Buchori, 2012; Ardiansyah and Buchori, 2014; Maulana and Buchori, 2016; Hapsoro and Buchori, 2015; Buchori et al., 2018). The strengthening efforts can start from the coming evaluation of the plan, which should be done once every five years.

A rearrangement of the coastal area can be considered an option as well. The fact that people prefer to stay rather than to migrate needs a proper attention. For example, the local government may conduct a programme to relocate them to a guaranteed safer place. For this, the local government can provide a new residential area relatively close to the previous location, but safe from the threat of *Rob*. Also, the new location should be supported by a convenient and inexpensive transportation system to allow the inhabitants to perform their daily activities more efficiently.

Another option is the provision of incentives or subsidies for those willing to be relocated by the local government. By considering their needs, it is expected that they can be voluntarily relocated away from the *Rob* zones. Thereafter, the local government will be able to rearrange the affected *Rob* areas. This rearrangement and relocation will be more comfortable when it is based on the wishes of the community (Reuveny, 2007). In the longer run, it will be more beneficial for both the community and the local government.

6. Conclusions

This study concludes that the community had made various structural mitigation efforts to overcome the *Rob* problems. It is worth noting that at the existing situation there was no significant difference between the measures of structural mitigation done by the communities living in the 2031 projected areas of permanent and temporary *Rob*. It means that the community awareness in both areas was relatively similar. The most common structural mitigation effort by the community had been to raise their houses and buildings. Meanwhile, the local government had taken several structural mitigation measures. Unfortunately, it had not yet undertaken non-structural measures that can assist the management of the *Rob* problems.

This study also shows that many inhabitants preferred to stay and adapt to the *Rob* hazards than to leave their current residential places. Social factors, such as being comfortable with their community relationships, were the main reasons. Among the few residents who wanted to move, the most preferred reason was the desire to seek a better living environment. Another reason was the desire to stay close to their friends or relatives. The preference to move to other *Rob* affected areas close to public facilities and downtown was rarely found in the Semarang case. It implies that those no longer able to adapt have no other choice than to move to safer places with just a little consideration on proximity to workplaces and public facilities.

For the local government, the primary challenge is how to encourage people to be more aware of the potential hydro-meteorological hazards that threaten their environment. Also, the local government needs to develop more permanent solutions to overcome this problem, and not just to rely on the temporary or short-term ones as having been undertaken so far. As one of the city's development plans, the City Spatial Plan should be improved to contribute in that kind of solutions. The evaluation and revision mechanism that should be done in every five years can be used to improve the quality of the plan.

Acknowledgements

This research is funded by a research grant of International Research Collaboration from the Directorate of Research and Public Services, Directorate General of Strengthening Research and Development, Ministry of Research, Technology, and Higher Education of the Republic of Indonesia. The authors would like to thank Dr. Yan Liu (School of Earth and Environmental Sciences, University of Queensland, Australia) for the valuable discussion about the topic and Mr Pangi and Ms Rolan Firmana for their help in data compilation and analysis. Any flaw or weakness is the responsibility of the authors.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ocecoaman.2018.07.017.

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