



Impact of Grouped Settlements on Disaster Risk Reduction in City of Kigali, Rwanda

Alexis Mugisha¹ and Lamek Nahayo¹

¹Faculty of Environmental Studies, University of Lay Adventists of Kigali, P.O.Box: 6392, Kigali, Rwanda

Abstract: The City of Kigali records flood, rainstorms and windstorms which affect people's livelihoods, particularly those located in disaster prone areas. This study assessed the role of grouped settlements on disaster risk reduction in City of Kigali (CoK) between 2015 and 2020. The authors mainly employed secondary datasets on disaster record, associated losses, types of building and location of grouped settlement. The data were collected from CoK and Ministry in charge of Emergency Management (MINEMA). The Microsoft Excel was the main tools of data collection and analysis. The results highlighted fire, rainstorms, windstorms, landslide, flood and lightning as key disasters recorded in CoK. Their occurrence caused 88 deaths and 76 injuries, damaged 4,571 houses and 742.1 hectares of cropland while 80 livestock were lost. High number of disaster loss was registered by Nyarugenge district with low number of grouped settlements in terms of re-allocated households. Nyarugenge district counts 579 while Kicukiro and Gasabo recorded 1,822 and 533 re-allocated households, respectively with low disaster losses than Nyarugenge. This expresses that large communities and properties in Nyarugenge district are exposed to disasters and that fewer intervention/insufficient efforts are under execution. The results of this research can facilitate policy makers in charge of settlements/housing management to better understand disaster prone and safe areas for future interventions towards saving lives and properties as well.

Key words: City of Kigali, Disaster risk reduction, Grouped settlements, Rwanda

1. Introduction

Recent disasters have brought institutional and community awareness of the importance of safe buildings and appropriate building locations in strengthening people's resilience to disasters. Building and land use regulations have proven a remarkably powerful tool for increasing people's safety and resilience and limiting the risk which people and their properties can face (Perera et al. 2019; Nejad et al. 2017).

In Rwanda, recent disasters which occurred have caused significant losses and damages among the vulnerable people. In the City of Kigali, for example, the residents located in flood prone areas have been subject to risk of flood and those with poor buildings (Bizimana and Schilling 2009). It was reported that approximately 5,000 ha of built up areas are prone to disaster in Kigali. This has led to significant losses between 2000 and 2019 where 27 people were affected (died/injured), houses collapsed and hectares of croplands were damaged. The Gasabo and Kicukiro districts of Kigali city are the largely affected by disasters compared to Nyarugenge district (Nikuze et al. 2019; Gasasira Higirow 2020).

In Kigali city, flooding ranks the first in impacting on people's livelihoods. The risk to floods is exacerbated by inefficient storm water management as a result of faster growth, poor drainage, and settling in flood prone areas. Recent study (Bizimana and Schilling 2009) on flood exposure analysis in the City of Kigali which incorporated vulnerable infrastructure, buildings, population and economic activities revealed that 27% of buildings were located in flood prone areas. In Kigali city, there is also occurrence of landslide, for example, a landslide incident registered in Kanombe sector of Kicukiro district destroyed one house, killed three family members, a mother and two children, while in another family of seven perished (Kigali City, 2019).

With reference to the World Bank report (2018), it is indicated that if countries rebuild strong, faster and more inclusively after disasters, they can reduce the impact on people's vulnerability and wellbeing by as much as 31%, potentially cutting global average losses from \$555 to \$382 billion each year. In addition, the same reports mentions that within poor countries such as island states and Sub-Saharan African countries facing more disasters, building back better policy would be more important where disaster risk reduction approaches are implemented made before the occurrence. This, if well executed, would contribute to reducing an annual loss on community's well-being by 14 percent equivalent to a US\$75 billion.

In their recent report (Nikuze et al. 2019) indicated that the Kigali Master Plan initiated in 2013 aimed to transform the city into a resilient and safe place. Nonetheless, the city's expansion has been accompanied with substantial unplanned development which attracted residents to settle in such landslide and flood prone areas. In addition, regardless the fact that grouped settlement policy is under implementation, losses caused by disaster occurrence even within the selected sites, are still under record.

Recent research conducted by Clement I., et al., (2021), indicated how much respect of building codes can contribute to minimizing disaster exposure in Kicukiro district of the City of Kigali. However, as by the researcher's best of knowledge, no existing research was conducted to analyze the extent to which grouped settlements contribute to disaster risks reduction. In case such research is conducted for the City of Kigali, more awareness on the major disasters occurring in the area can be recognized, their associated losses and the difference in the risk exposure within Districts of Kigali City. Therefore, this study was conducted to analyze the impact of grouped settlements in disaster risk reduction. The research was conducted in the City of Kigali within a period ranging between 2015 and 2020.

2. Materials and Methods

2.1 Description of study area

This study considered the City of Kigali as case study which is becoming more exposed to disasters mainly flooding, landslide and heavy rains, and the community located in prone areas are largely affected. Both Gasabo and Kicukiro district are the main parts of the city largely affected by disasters (Nikuze et al. 2019). In addition, as recently reported (Nkubito 2016; River 2015), in Kicukiro district, storm water runoff has created a natural earth channel which is continuously increasing in width due to storm water which carries soil particles of the channel and the channels undergo side slope failure and excessive increase of depth due to scouring. This exposes the community to associated losses mainly during heavy rainfall.

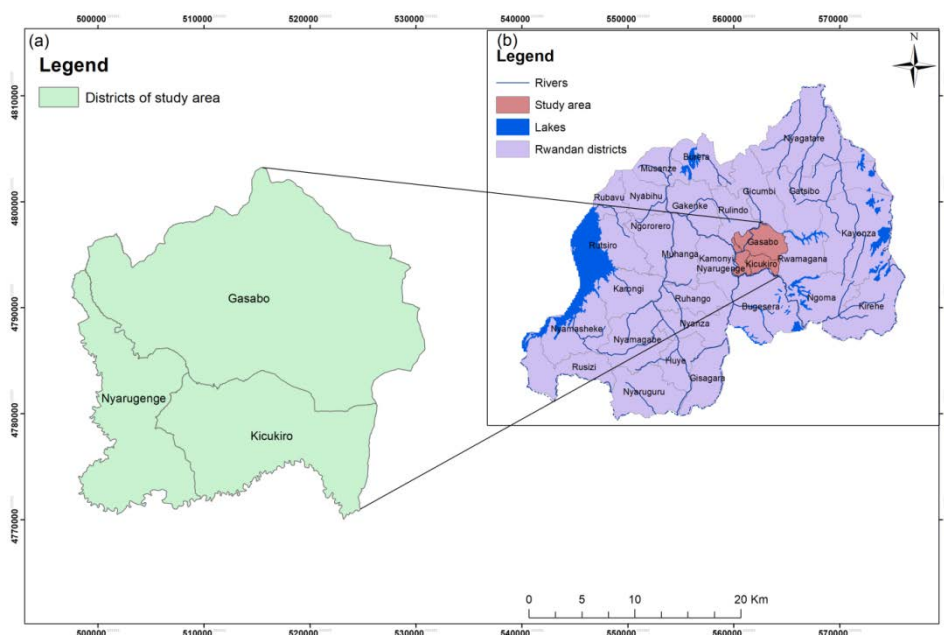


Figure 1: Map indicating (a) districts of CoK and (b) its bordering districts of Rwanda
 Source: Authors, 2022

2.2 Data Collection and Analysis

For this study, the employed secondary data were composed by types of current adopted settlement types, areas in which people were re-allocated as disaster safe areas from disaster prone areas across the City of Kigali. The utilized data also were related to the types of disasters recorded and associated losses like killed/injured people, damaged cropland, destroyed houses, bridges and roads within the research period (2015-2020). This enabled authors to detect changes on disaster risks within Districts of Kigali City with grouped settlements and indicate whether there has been reduction of risks or not. The data were analyzed by using Chart and Tables generated by Microsoft Excel.

3.Results

The results in Table 1 illustrated the building codes which have been applied to every sector and some changes which were made by the City of Kigali management, and they were adopted since 2013. In order to better understand the employed building codes in the City of Kigali, the researcher utilized the labelling of each building codes for easy interpretation.

3.1 Grouped settlements types and location

Table 1: Initiated building codes in Kicukiro district

Building codes	Meaning
A1 and R1A	Agricultural and low density residential densification zone
R2	Medium density residential improvement zone
A1, C1	Agricultural and mixed use zone
From R1A to R2	Low density residential densification zone to Medium density residential improvement zone
From R3 to R1A	Medium density residential, expansion zone to Low density residential densification zone
From R1A to R2	Low density residential densification zone to Medium density residential improvement zone
From R4 to C3	High density residential zone to City commercial zone
From R1A to R4	Low density residential densification zone to High density residential zone
A1	Agricultural zone
From R1A to R3	Low density residential densification zone to Medium density residential, expansion zone
Increased I1, I2 and C3	Light industrial zone, General industrial zone and City commercial zone
PF2 and PF3	Health and Religious facilities
From I2 to R3	General industrial zone to Medium density residential, expansion zone
C3	City commercial zone
PF5, PF2 and PF1	Cemetery, Health and Religious facilities

Source: City of Kigali, 2022

It is good to remind that these building codes are applied to individuals and companies building houses in the City of Kigali. But also, they are applied in case the Government needs to relocate the community from hazard prone areas to safe areas. They have been under operation since 2015 to date. This expresses that the results in Table 2 on the location of grouped settlement across CoK respected the above building codes in order to minimize people's exposure to disaster risk.

Despite the disaster losses which were recorded in the previous years (2015-2020) considered by this research, it can be noted that the management of City of Kigali did its best to relocate people form hazard prone areas to safe area as shown in Table 2, Kicukiro district recorded higher relocation number (1,822) followed by Nyarugenge district at 579 while Gasabo district recorded 533 people re-allocated.

Table 2: Grouped settlements location

District	Grouped settlement sites	Household (s) re-allocated	Total
Nyarugenge	Iterambere	54	579
	Rugendabari (IDP)	88	
	Kamatamu	100	
	Makaga	97	
	Karama (IDP)	240	
Gasabo	N/N	421	533
	Rudakabukirwa (IDP)	112	
Kicukiro	N/N	1,501	1,822
	Ayabaraya (IDP)	120	
	Gicaca & Cyankongi	201	
Total			2,934

IDP: Intergraded Development Program, N/N: Not known

Source: City of Kigali, 2022

3.2 Disaster occurrence and losses

With regard to disaster occurrence and associated losses, the authors considered the losses registered between 2015 and 2020 by districts in Kigali City. These disasters were mainly fire, landslide, flood, windstorms, rainstorms, hailstorm, houses collapsed along with lightning. The resulted losses considered by this research were mainly deaths, injuries, houses damaged, damages in cropland, lost livestock, destructed classrooms, health centers, roads, churches, bridges, and administrative offices, water supply, transmission lines along with markets and factories destructed. More details on recorded disaster and losses between 2015 and 2020 are provided Tables 3, 4, 5, 6, 7 and 8.

The findings of the study shown in Table 3 indicate that in 2015, fire, lightning and rainstorms were recorded with huge impact on cropland and houses where the damaged croplands were 103 hectares along with 87 houses in Gasabo district. Gasabo district was highly affected compared to its counterparts Kicukiro and Nyarugenge districts (Table 3).

Table 3: Disaster loss records in 2015

Event	District	Houses Damaged	Damages in crops Ha.	Administrative offices	Transmission lines
Fire	Kicukiro	9	0	0	0
Fire	Nyarugenge	1	0	0	0
Lightning	Gasabo	0	0	0	2
Rainstorms	Gasabo	87	103	1	0
Rainstorms	Kicukiro	26	0	0	0
Rainstorms	Nyarugenge	2	0	0	1
Total		125	103	1	3

Source: MINEMA, 2020

With regard to the year 2016, the results in Table 4 revealed that fire, rainstorms and windstorms were registered in the City of Kigali. The largely affected district was Gasabo which registered 346 houses destroyed by both rainstorms and windstorms. The number of deaths, damages on roads, churches, administrative offices and transmission lines was quite low with one (1) each compared to the destroyed houses which recorded 509 cases across all three districts of Kigali city (Table 4).

Table 4: Disaster loss records in 2016

Event	District	Deaths	Injured	Houses Damaged	Roads	Churches	Administrative offices	Transmission lines
Fire	Kicukiro	0	2	6	0	0	0	0
Fire	Nyarugenge	0	3	0	0	0	1	0
Rainstorms	Gasabo	1	3	208	0	0	0	0
Rainstorms	Kicukiro	0	0	116	0	0	0	0
Rainstorms	Nyarugenge	0	0	37	1	0	0	0
Windstorms	Gasabo	0	0	138	0	1	0	11
Windstorms	Kicukiro	0	0	4	0	0	0	0
Total		1	8	509	1	1	1	11

Source: MINEMA, 2020

In addition, as shown in Table 5, in 2017, the affected factory (1) registered in Nyarugenge district was the newly registered among the other disaster losses recorded in previous years (2015 and 2016). The same Table 4.5 showed that Nyarugenge recorded high number of houses (754) and classrooms (16) which were damaged by rainstorms. However, in 2016 (Table 4), the deaths recorded (1) gradually increased in 2017 and reached 13 mainly in Gasabo district.

Table 5: Disaster loss records in 2017

Event	District	Deaths	Injured	Houses Damaged	Classrooms	Roads	Churches	Bridges	Transmission lines	Factory
Fire	Kicukiro	0	0	2	0	0	0	0	0	0
Flood	Kicukiro	1	0	0	0	0	0	0	0	0
Flood	Nyarugenge	1	0	0	0	0	0	0	0	0
Rainstorms	Gasabo	8	4	120	0	0	1	0	0	0
Rainstorms	Kicukiro	1	2	79	0	0	0	0	0	0
Rainstorms	Nyarugenge	2	0	754	16	4	2	1	3	1
Total		13	6	955	16	4	3	1	3	1

Source: MINEMA, 2020

In 2018, as shown in Table 6, rainstorms were the major disaster which affected houses since the damaged were 1,393 and 927 in Nyarugenge and Kicukiro district, respectively. The same disaster (rainstorms) also, at high extent, affected the cropland by damaging 377.5 and 206.6 hectares of cropland within Kicukiro and Nyarugenge districts, respectively (Table 6).

Table 6: Disaster loss records in 2018

Event	District	Deaths	Injured	Houses Damaged	Damages in crops Ha.	Classrooms	Churches
Fire	Kicukiro	0	0	1	0	0	1
Flood	Gasabo	0	0	30	0	0	0
Landslide	Gasabo	9	5	4	0	0	0
Landslide	Kicukiro	0	0	1	0	0	0
Lightning	Gasabo	1	0	0	0	0	0
Rainstorms	Gasabo	8	4	927	377.5	0	0
Rainstorms	Kicukiro	9	6	111	0	0	0
Rainstorms	Nyarugenge	8	17	1,393	206.6	2	0
Windstorms	Nyarugenge	0	0	4	0	0	0
Total		35	32	2,471	584.1	2	1

Source: MINEMA, 2020

Furthermore, as shown in Table 7, new disaster loss was registered such house collapse which led to 6 deaths and 5 injuries in Kicukiro and Nyarugenge districts. Similar to previous years (2015, 2016, 2017 and 2018), the number of houses damaged by disasters mainly rainstorms kept on increasing. In 2019, 100 houses were damaged in Nyarugenge district along with 68 houses damaged in Gasabo district due to the rainstorms.

Table 7: Disaster loss records in 2019

Event	District	Deaths	Injured	Houses Damaged	Damages in crops Ha.	Classrooms	Roads	Bridges	Administrative offices	Transmission lines	Markets
Fire	Kicukiro	1	0	3	0	0	0	0	0	0	0
Fire	Nyarugenge	0	0	4	0	0	0	0	0	0	1
Flood	Gasabo	0	0	7	0	0	1	0	0	0	0
Flood	Kicukiro	0	0	6	5	0	0	1	0	0	0
Hailstorms	Gasabo	0	0	0	15	0	0	0	0	0	0
House collapse	Kicukiro	1	4	3	0	0	0	0	0	0	0
House collapse	Nyarugenge	5	1	2	0	0	0	0	0	0	0
Landslide	Gasabo	0	1	2	0	0	1	1	0	0	0
Rainstorms	Gasabo	1	2	68	15	8	1	1	2	1	0
Rainstorms	Kicukiro	1	2	50	0	0	0	0	0	0	0
Rainstorms	Nyarugenge	1	1	100	20	0	1	1	1	0	0
Windstorms	Gasabo	0	0	13	0	0	0	0	0	0	0
Windstorms	Nyarugenge	0	0	4	0	3	0	0	0	0	0
Total		10	11	262	55	11	4	4	3	1	1

Source: MINEMA, 2020

The last year considered by this research (2020) indicated a quite similar number of disaster occurrence where the major recorded were flooding, landslide, windstorms and rainstorms (Table 8) as previous years (2015-2019). The year 2020 recorded low number of losses

compared to previous years. For example, the damaged houses were 250 against 509 damaged houses in 2016, 955 damaged houses in 2017 and 2,471 houses damaged in 2018 (Tables 4, 5 and 6).

Table 8: Disaster loss records in 2020

Event	District	Deaths	Injured	Houses Damage	Livestock	Roads	Bridges	Administrative offices	Transmission lines	Markets
Flood	Gasabo	7	1	4	0	1	1	0	0	0
Flood	Nyarugenge	2	1	0	0	3	0	0	0	0
Landslide	Gasabo	12	0	3	0	0	0	0	0	0
Landslide	Nyarugenge	1	0	12	0	2	0	0	0	0
Rainstorms	Gasabo	2	8	98	0	0	0	0	2	1
Rainstorms	Kicukiro	5	8	73	0	6	1	0	0	0
Rainstorms	Nyarugenge	0	1	53	80	1	0	1	1	0
Windstorms	Kicukiro	0	0	6	0	0	0	0	0	0
Windstorms	Nyarugenge	0	0	1	0	0	0	0	0	0
Total		29	19	250	80	13	2	1	3	1

Source: MINEMA, 2020

3.3 Grouped settlement and disaster risk

With regard to the general disaster loss cases recorded between 2015 and 2020, the results in Table 9 showed that Nyarugenge district recorded high number of cases (2,762). The Kicukiro and Gasabo districts registered only 33 and 8 disaster loss cases, respectively. It can be noted that Nyarugenge district is largely prone to disasters than Gasabo and Kicukiro districts. The same Table 9 showed that the total number of households re-allocated from disaster prone areas in Nyarugenge district is low (579) compared to the number of disaster loss cases (2,672) recorded while in Kicukiro and Gasabo districts, the record reveals contrary case to that of Nyarugenge district.

It was realized that high number of re-allocated households in grouped settlements (1,822 and 533 for Kicukiro and Gasabo, respectively) is higher than the recorded disaster loss cases of 33 and 8 in Kicukiro and Gasabo districts, respectively. This expresses that disaster are still occurring in the City of Kigali and that people and their properties are exposed as well since the re-allocation does not appropriately consider those in high risks. In addition, based on the results presented in Table 9, it can be noted that Nyarugenge district with high number of disaster loss cases needs more attention in re-allocating people in grouped settlement in order to save lives. This can be made possible by choosing the right areas in Nyarugenge district which are not prone to disasters or re-allocating residents from Nyarugenge districts to either Gasabo or Kicukiro districts, assumed to be safe due to their low number of disaster loss cases (Table 9).

Table 9: Summarized disaster cases and grouped settlement (2015 – 2020)

Districts			
	Kicukiro	Nyarugenge	Gasabo
Disaster (s)	Number of disaster loss cases		
Fire	25	10	0
Flood	0	7	0
House collapse	8	8	8
Landslide	0	15	0
Rainstorms	0	2,711	0
Windstorms	0	11	0
Total	33	2,762	8
Grouped settlements			
Re-allocated	1,822	579	533

Source: MINEMA, 2020 and CoK, 2020

Accordingly, with regard to disaster loss per case, the results in Table 10 showed that Nyarugenge district is highly affected by disasters with a total of 2,763.6 losses followed by Gasabo district with 2,333.5 losses. In terms of deaths and cropland damages caused by disasters, Gasabo district ranks the first with 49 and 742.1 ha of cropland, respectively. Nyarugenge district ranks first in terms of loss of house damages and livestock lost at 2,366 and 80, respectively (Table 10).

Table 10: Disaster loss case per district (2015-2020)

Loses	Nyarugenge	Kicukiro	Gasabo	Total
Deaths	20	19	49	88
Injuries	24	24	28	76
House damage	2,366	496	1,709	4,571
Cropland damage	226.6	5	510.5	742.1
Livestock	80	0	0	80
Classrooms	21	0	8	29
Roads	12	6	4	22
Churches	2	1	2	5
Bridges	2	2	3	7
Administrative offices	3	0	3	6
Transmission lines	5	0	16	21
Markets	1	0	1	2
Factory	1	0	0	1
Total	2,763.6	553	2,333.5	

Source: MINEMA, 2020

4. Discussion

Globally, disasters are causing immense losses mainly within grouped communities. Disaster risk is disproportionately concentrated in developing countries which have more vulnerable economies, often weak governance structures and high poverty levels (Nduwayezu et al. 2015). It is reported that disaster risk and poverty are interrelated and the poor suffer most the

effects of damage and losses caused by intense exposure to natural hazards. Most of the African countries are regularly affected by severe and often multi-year disasters. However, all areas within Africa are not equally vulnerable to these disasters (Kuol 2019).

In addition, as long as human population increases, people move from one location to another search for safe place to build in their houses. In most of the times, due to lack of sufficient information on disaster causes and poverty as well, they locate in disaster prone area and build unstable houses with poor materials. This in return, leads to huge losses when a disaster hits their neighborhood. Several governments and other private institutions invest in moving people from high risk zone to safe zone (Kuol 2019; Rugigana et al. 2013). For Rwanda, as shown in Table 1, building codes/types are proposed and sometimes, the government relocates people from disaster prone to safe areas as it is done in the City of Kigali (Table 2)

Nevertheless, the locations in which people are re-located in are sometimes exposed to future disasters. This results from the fact that people were removed without prior consultancy and/or study of the area to be used for allocating people in terms of disaster exposure simply because it was vacant. Rwanda, because of its geographical feature and climatic profile is one of the Sub-Sahara African countries prone to disasters and especially localized in landslides and floods prone zones. Many cases of disasters underlined in Rwanda are particularly linked to the geographic characteristics, historical and socio-cultural aspects of the country (Nduwayezu et al. 2015).

In the context of Rwanda, the key disasters under record are the flooding, landslides, windstorms, rainstorms and hailstorms. The causes of vulnerabilities to disasters include geographic characteristics such as steep slopes and others (MINEMA 2020). This was again confirmed by the results of this research where the major recorded disasters in the City of Kigali are flood, landslide, windstorms, rainstorms (Tables 4-8). Accordingly, as recently reported (Patterson et al. 2010; Shaw 2012; Siagian et al. 2014), new cases of disasters are being recorded among communities mainly due to the changing climate and modification of the natural landscape. This can be attributed to the case of City of Kigali, since 2015 to 2020, only fires, lightning and rainstorms were recorded in 2015. However, since 2016 to 2020, windstorms, landslide, house collapse and flood were registered and they led to severe losses in terms of death, injuries and cropland damage along with house damages (Tables 4-8).

Moreover, it is good to consider the fact that, as recently reported, areas which recorded disasters in the past are likely exposed to future occurrence. This agrees with the results of this study (Tables 3-8) where Nyarugenge district stands at high extent in terms of being

affected and has been recording the same rank from 2015 to 2020. However, it was realized that in Nyarugenge district, less efforts are made in terms of grouping people into safe settlement, the available data indicate big number compared to Kicukiro and Gasabo districts (Table 9 and 10). This expresses that more efforts are still needed to ensure people's safety in Nyarugenge district and that involving these communities in areas selection before their relocation would help. Moreover, it is good to use Kicukiro and Gasabo districts with low number of disaster loss and grouped settlement.

5. Conclusion

This study aimed to determine the extent to which relocating people from disaster prone areas to safe areas within grouped settlements contribute to disaster risk reduction in the City of Kigali. The study shows that between 2015 and 2020, increasing number of disasters was recorded by residents of City of Kigali. These were mainly fire, rainstorms, windstorms, landslide, flood and lightning. These disasters led to 8 loss cases in Gasabo district, 33 loss cases in Kicukiro and 2,672 loss cases in Nyarugenge district. However, it was noted that grouped settlements are few in Nyarugenge district largely affected in terms of all registered losses. Only 579 households were re-allocated compared to 533 and 1,822 re-allocated households in Kicukiro and Gasabo districts with low disaster loss. The study concludes that current grouping of community settlement is not working properly since the area largely affected by disasters has low number of grouped settlements which were developed with the aim of saving people's lives and properties as well. Hence, further efforts in better selecting locations of grouped settlements and ensuring that the newly-established settlements are resistant to disasters (based on local context) are needed. Policy makers will benefit from this research to better recognize the way forward toward disaster risk reduction under grouped settlement policy.

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