Assessing local community resilience to tsunami in a small port (Case Study: Sadeng Port, Indonesia)

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Abstract. Coastal community is vulnerable to hazards including tsunami hazard. Coastal communities suffer the most both physical and psychological impacts. The main purpose of this research to assess local community resilience to tsunami in small port which has a unique characteristic. Main data of this research was collected by field observation and interview. Interview process were addressed to key persons and households. USAID coastal community assessment is used as main method in this research. There are eight elements of resilience for coastal community resilience: governance, society and economy, coastal resource management, land use and structural design, risk knowledge, warning and evacuation, emergency response and disaster recovery. The results show that overall rating for eight elements of community resilience is 2.5 or 50 %. It is only halfway to reach an ideal criterion for community resilience. Strong elements in this community are risk knowledge and warning and evacuation, while weak elements are society and economy, coastal resource management, and disaster recovery. The community should gain more effort especially in developing a sustainable economy and strengthening integration among stakeholders for disaster recovery.

Keywords: resilience, local community, tsunami

1. Introduction
Building resilient communities have been recognized as a focus on disaster risk reduction. Improving institution structure and capabilities to build hazard resilience has been mentioned as one of the strategic goals in the Hyogo Framework for Action 2005-2015 [1]. Sendai Framework for Disaster Reduction 2015-2030 renewed commitment for building resilience in focused on sustainable development and poverty reduction [2]. Resilience is the capability of a system, community, or society threatened to hazard to survive, adapt and get back from the effects of hazard in a reliable condition [3]. Building community resilience requires an integration of several stakeholder elements. Coastal community is vulnerable to hazards including tsunami hazard. Indian Ocean tsunami 2004 became a turning point in terms of disaster risk reduction, especially in Indonesia. Coastal communities suffer the most both physical and psychological impacts [4]. Local communities in Indonesia today are highly vulnerable to disaster and threatened by future disasters [5]. As many as
tsunami events in the world occurred in Indonesia with the major events located in Aceh, Java, Flores, Mentawai, Halmahera, Sulawesi, and Papua [6]. Communities in those locations particularly live in high risk of tsunami hazard.

Resilient communities are required for enhancing disaster risk reduction. Resilient communities have six characteristics include: a) knowledgeable and healthy; b) well organized; c) well connected; d) good infrastructure and services; e) high economic opportunities; and 6) capability to manage its natural assets [7]. Also, resilience communities are capable to cope the damages resulted by hazard and recover by utilizing their own resources [8]. Tsunami-resilient communities have the following criteria: understanding tsunami hazard, having plans and tools for tsunami mitigation, sharing tsunami hazard information, understanding how to save themselves, having adaptation and recovery action plans to get back better [9],[10].

Port is one of the centers of activities in coastal area that constantly impacted by tsunami [11],[12]. Activities at the port can be transportations, trades, and fisheries. Port is prone to earthquake, tsunami, and liquefaction hazard due to its location close to sea level and built on unconsolidated material [13]. Improving tsunami resilience for port communities became main priority to reduce disaster impacts [14].

Sadeng is a small port in Gunungkidul coastal area which is directly facing Indian Ocean. The main function of this port is as a fishing port. Apart from having various infrastructures to support fishing port function, Sadeng port is inhabited by fishermen’s group who are partly nomadic and come from various regions in Indonesia [15]. Villagra et al [16] mentioned that level of resilience may vary based on their social, politic, urban, rural, and native characteristics of certain area. Morin et al [17] stated that people who are well-educated about tsunami basic knowledge tend to be survived from tsunami events. Indigenous knowledge provided valuable knowledge for people to act during pre-tsunami, tsunami, and post-tsunami [18]. Currently, previous researches focused on the characteristics on tsunami-resilient communities whereas strength and weakness in local community to be tsunami-resilient still have deficient discussion.

The main purpose of this research to assess local community resilience to tsunami in small port which has a unique characteristic. Local community resilience assessment is aimed to identify strength and weakness of local community to cope tsunami hazard. The results provide: a) strength elements in community resilience which can be a lesson learned to other regions; and b) weak elements which should be improved to enhance community resilience.

2. Methods

Study area is in Sadeng port, a small port located in Songbanyu Village, Gunungkidul Regency, Yogyakarta. Sadeng port is situated in a bay and valley surrounded by a high and steep cliff on both sides (Fig 1). Land use types in Sadeng port includes port infrastructure, fish market, settlements, and dry agriculture land [15].
USAID [4] has developed coastal community framework and benchmark for disaster management. There are eight elements of resilience for coastal community resilience: governance, society and economy, coastal resource management, land use and structural design, risk knowledge, warning and evacuation, emergency response and disaster recovery (Fig 2). Description for each element of coastal community resilience is shown in Table 1. All elements in coastal community resilience are related and influence each other. The ratings in each element are manifested with a rating ranging from 0 to 5 (Table 2). This rating does not show the level of resilience but shows the current condition of resilience compared to ideal resilience conditions.

**Figure 1.** Research area location

**Figure 2.** Elements of coastal community resilience [4]

| Elements               | Description                                                                 |
|------------------------|-----------------------------------------------------------------------------|
| Governance             | Government supports communities to adapt and get back better by providing policies, programs, leadership, and legal framework |
| Society and economy    | Society and economy give direct influences on                                |
communities’ livelihood in term of disaster preparedness, adaptive capacity, and recovery speed.

Coastal resource management
Coastal resource management functions to manage and maintain valuable resources in coastal area to support community’s live both pre-disaster and post-disaster.

Land use and structural design
Useful land use management and well-structured infrastructure minimize potential impacts of disaster.

Risk knowledge
Risk knowledge rise community awareness about potential hazard and negative impacts of disaster for them.

Warning and evacuation
Warning and evacuation are a crucial part in disaster management. Effective warning and evacuation prepare communities to act faster during the disaster events.

Emergency response
Adequate emergency response supports communities to protect their lives.

Disaster recovery
Disaster recovery helps communities to recover and get back better from the disaster impacts in term of livelihood and basic services.

| Rating | Description |
|--------|-------------|
| 0      | Condition absent |
| 1      | Poor (1 to 20 percent fulfilled) |
| 2      | Fair (21 to 40 percent fulfilled) |
| 3      | Good (41 to 60 percent fulfilled) |
| 4      | Very Good (61 to 80 percent fulfilled) |
| 5      | Excellent (81 to 100 percent fulfilled, sustainable) |

Main data of this research was collected by field observation and interview. Interview process were addressed to key persons and households. Key persons in this research were leader of fishermen group, leader of SAR (Search and Rescue) and local government officer. The key persons were determined by snowball sampling method. Sadeng port population consists of around 300 persons and 80 households. We interviewed all of households in the Sadeng port. Interviews on key persons and households were conducted to obtain more accurate data from two different perspectives for each element.

3. Results and Discussion

3.1. Governance
Good governance facilitates community to enhance their resilience through appropriate policies, programs, and leadership. There are several benchmarks for assessing governance elements that is showed in Table 3. Local government represented by BPBD (National Agency of Disaster Management) Gunungkidul has conducted regular tsunami risk assessment and evaluation with uncertain timing range. The tsunami risk assessment is held by BPBD in collaboration with NGOs and academics party. Tsunami risk assessment involves the community, especially DESTANA (Desa Tangguh Bencana) officials. Government launched DESTANA program to enhance community resilience to tsunami for coastal villages. DESTANA was established at the village level but in the
Sadeng port case, only few of fishermen community were involved in DESTANA. DESTANA is a program originating from the central government and implemented at the village level. The potential resources and culture of the fishermen community in Sadeng port have not been considered in the disaster risk management program. The overall rating for governance elements is 2.5 or 50% of the ideal rating. The role of government in improving community resilience has been sensed by the community. However, it needs to be improved in involving local communities more in the disaster risk reduction program. The local community can be actively involved in the program so that the program can be implemented in line with the characteristics of community.

| Table 3. Benchmark and rating of governance |
|--------------------------------------------|
| **Benchmark**                              | **Rating** |
| Government assess and evaluate tsunami risk routinely | 3 |
| Government involves community to conduct tsunami risk assessment | 2 |
| Government provide plans and programs to enhance community resilience | 3 |
| Government provide basic needs (water, health, sanitation, education, security) efficiently | 3 |
| Public facilities and infrastructure remain operated during disaster events | 2 |
| National and local government policies related to tsunami risk management are well integrated | 3 |
| Disaster risk management programs consider potential resource and culture of the community | 2 |

**Average** 2.5

3.2. Society and economy

Society and economy directly influence social vulnerability. People in poverty tend to be more difficult to bounce back when a disaster occurs. For marginalized communities, assistance from society will be valuable to restore their lives after a disaster [19]. Benchmarks on society and economy elements are described in Table 4. This element focuses on the strength of the organization in the community and the economic capacity to deal with the tsunami. The fishermen community in Sadeng port has a specific organization in tsunami disaster management consisting of community coordinators and a SAR team. This organization already has a good tsunami disaster mitigation program. Fishermen community has mutual funds, but the funds are not specifically intended for tsunami emergency response and recovery. However, it does not rule out if the funds are used during an emergency response.

All respondents in Sadeng port have their main livelihood as fishermen. As many as 51% of the respondents have a side job apart from fishermen include trading and farming. In terms of livelihood diversity, people in Sadeng port are very dependent on the fisheries sector. Dependence on one economic sector can lead to poor resilience. If a tsunami occurs, their livelihoods will be lost. The government through the Ministry of Maritime Affairs and Fisheries provides training programs for alternative livelihoods for fishermen and provides programs related to fishermen economic development. The training consists of industrialization of fisheries and quality life improvement. However, this program is not sustainable, so the effects of this program have not been seen.

As many as 91% of the people in Sadeng port do not have emergency funds for disasters. In addition, they also do not have sufficient assets to support their life post-tsunami. Most of the assets are movable assets such as motor vehicles and ships. Asset in property is only owned by 3% of all
respondents. The existence of this asset is very important in relation to the ability to bounce back better after a disaster. If all the assets are lost by the tsunami, the community will have difficulty building their lives again. The elements of society and economy are classified as low with a rating of 2 or 40%. This element needs to be improved a lot, especially in the economic aspect, includes diversification of livelihoods and addition of economic assets.

Table 4. Benchmark and rating of society and economy

| Benchmark                                                                 | Rating |
|--------------------------------------------------------------------------|--------|
| Community have a specific organization for tsunami risk reduction         | 3      |
| Community provide tsunami mitigation program                              | 3      |
| Community have an insurance and assets for recovery process after tsunami| 1      |
| Community have a special fund collected among them for tsunami emergency response and recovery | 1      |
| Community have various livelihood, not only one type of livelihood       | 2      |
| Existence of institution supported sustainable economic development        | 2      |
| Existence of training program for alternative livelihood                  | 2      |
| **Average**                                                              | **2**  |

3.3. Coastal resource management

Coastal resource management planning and strategies are conducted by local governments (Table 5). Coastal resource assessments are conducted regularly but with uncertain timeframes. Community involvement in planning and implementation of coastal resource management is still low. The community has realized the importance of coastal resources for their lives, but the community has not had real action to implement coastal resource management. This element has a mean rating of 2 or 40%. This element needs to be improved by increasing community awareness to participate in coastal resource management.

Table 5. Benchmark and rating of coastal resource management

| Benchmark                                                                 | Rating |
|--------------------------------------------------------------------------|--------|
| Existence of coastal resource management planning and strategies         | 2      |
| Regular assessment of coastal resource potential                         | 2      |
| Existence of coastal resource zonation for conservation                  | 3      |
| Involvement of community in planning and implementing coastal resource management | 2      |
| Community is aware of the importance of coastal resource management and invest to sustain them | 1      |
| **Average**                                                              | **2**  |

3.4. Land use and structural design

Benchmark for land use and structural designed is shown in Table 6. Earthquake and tsunami resistant building standards are regulated by the central and local governments. This is implemented in government buildings and infrastructure located at Sadeng port. Regional spatial planning is regulated by the local government. Based on the spatial pattern plan for Gunungkidul Regency in 2010-2030, the Sadeng Port area is not designated as a settlement area but dry land agriculture. The fishermen community in Sadeng port has knowledge of tsunami resistant structures. However, most of the
residential buildings in Sadeng port are vulnerable to tsunamis. The buildings are mostly built by wood with a weak structure. This is because the community does not have enough funds to build tsunami-resistant houses and considers the houses to be temporary residences. The land use and structural design elements have an overall rating of 2.2 or 44%. This element needs improvement, especially in the suitability of land use with regional spatial planning and improvement of building quality.

| Table 6. Benchmark and rating of land use and structural design |
|-----------------------------|----------------|
| Benchmark                                      | Rating |
| Existence of standard and regulation about earthquake and tsunami resistant building | 3 |
| Appropriate land use planning           | 2 |
| Design and structure of public infrastructures which consider tsunami hazard | 3 |
| Community have knowledge about tsunami resistant building | 2 |
| Community live in the tsunami resistant building | 1 |
| **Average**                                                   | **2.2** |

3.5. Risk knowledge
Risk knowledge element have several benchmarks explained in Table 7. Tsunami risk assessment are regularly conducted by local government. Community participation in tsunami risk assessment needs to be improved. Fishermen community in Sadeng port is very aware about tsunami risk in their area. Training for disaster management are held regularly by BPBD Gunungkidul and SAR team. Overall for this element have good rating as many as 3.2 or 62%.

| Table 7. Benchmark and rating of risk knowledge |
|-----------------------------|----------------|
| Benchmark                                      | Rating |
| Regular tsunami risk assessment                   | 2 |
| Community participation in tsunami risk assessment | 3 |
| Community is well-understand about tsunami risk        | 4 |
| Community know tsunami risk at household level in the surrounding area | 3 |
| Existence of training and information sharing about tsunami risk | 4 |
| **Average**                                                   | **3.2** |

3.6. Warning and evacuation
Benchmark of warning and evacuation element is described in Table 7. Community receive earthquake and tsunami information from BMKG (Agency of Meteorology, Climatology, and Geophysics) server. Community share the information through SMS and social media network among them. Warning and evacuation procedure during tsunami are coordinated by trained volunteer. They ensure that all of people are safe. There is an early warning system for tsunami owned by BMKG and BIG (Geospatial Information Agency). Public information of hazard zone and evacuation route is displayed in strategic places (Fig 3). Warning and evacuation element have a good rating of 3.3 or 66%. This element needs to be improved in coordination during evacuation process.
Table 8. Benchmark and rating of warning and evacuation

| Benchmark                                                                 | Rating |
|---------------------------------------------------------------------------|--------|
| Community receive emergency information from national and regional system | 4      |
| Community share emergency information to others                           | 3      |
| Community have evacuation plan and procedures for tsunami                 | 3      |
| The early warning system is well-functioned and well-maintained           | 3      |
| The existence of public information about hazard zone, evacuation route, shelters, and safe areas (map and sign) | 4  |
| The existence of volunteers in community who provide emergency information and coordinate during evacuation process | 3 |
| **Average**                                                               | **3.3**|

Figure 3. Hazard map and early warning system

3.7. Emergency response

Emergency response elements have several benchmarks described in Table 9. Community provide emergency response plan which was coordinated by small group in their neighbourhood. But the emergency response team still do not have detailed and specific tasks so that sometimes they misunderstood. Basic needs include food, water and electricity was fulfilled by government. Community also share their own resource to be used together during emergency response. Government regularly conduct tsunami simulation training once in a month. Overall rating for this element is 2.6 or 56 %. Some improvement is required in detailing tasks for emergency response team.

Table 9. Benchmark and rating of emergency response

| Benchmark                                                                 | Rating |
|---------------------------------------------------------------------------|--------|
| Community have specific emergency response plans                          | 2      |
| Existence of emergency response team with detailed and specific tasks     | 2      |
| Basic needs (food, water, electricity) during disaster can be fulfilled   | 3      |
| Community conduct regular training for tsunami emergency response         | 4      |
| Identification resources owned by community that can be used together during emergency response | 3 |
| **Average**                                                               | **2.8**|
3.8. Disaster recovery
Disaster recovery benchmark is explained in Table 10. Local community already have disaster recovery plan, but it is only for short-term goals. Disaster recovery process was conducted mostly by government. Government provide technical assistance for tsunami survivor. This element rating is valued 2 or 40 %. This low rating in disaster recovery elements due to low integration between stakeholders and there were no long-term recovery goals.

| Benchmark | Rating |
|-----------|--------|
| Community have disaster recovery plans which provide long-term recovery goals | 1 |
| There is a coordination mechanism with stakeholders regarding disaster recovery | 2 |
| Existence of technical assistance for tsunami survivor | 3 |
| Average | 2 |

3.9. Community resilience
Based on the analysis of eight elements, coastal community resilience in Sadeng port is described in Fig 4. The highest rating among elements are warning and evacuation and risk knowledge. Both elements become the strength for fishermen community in Sadeng port. Community in Sadeng port already have a good risk knowledge and appropriate program for warning and evacuation. Weakness in the community is shown at the lowest rating elements include society and economy, coastal resource management, and disaster recovery. Local community in Sadeng port need to improve these elements. Overall rating for eight elements is 2,5 or 50 %. It means community resilience in Sadeng port should be increased by another 50 %.

![Figure 4. Results of coastal community resilience elements](image)

4. Conclusion
Disaster risk reduction nowadays focus on building community resilience. Overall rating for eight elements of community resilience is 2,5 or 50 %. It is only halfway to reach an ideal criterion for community resilience. Strong elements in this community are risk knowledge and warning and evacuation, while weak elements are society and economy, coastal resource management, and disaster recovery. The community should gain more effort especially in developing a sustainable economy and strengthening integration among stakeholders for disaster recovery.
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