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*Article*

# Translating GPDRR UNDRR 2022, Sendai Framework, and the Bali Agenda for Resilience into Action: Mangrove-Nature Based Solutions and Local Wisdom in Mitigating Sea Level Rise Flood Disasters In Indonesia

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**Abstract** The recent global calamity of sea level rise and flooding is a major disaster. Some settlements on Java Island, Indonesia, have been reported to be sinking. Bedono Village is one village on the Central Java Coast that is vulnerable to sea level rise. Aside from the possibility of sea level rise, the calamity in this village is linked to prior mangrove degradation and fish pond expansion. This tragedy has displaced 78.63% of the population over a decade, and the remaining population is still surviving in the remaining lands. This study aims to investigate the effects of sea-level rise-related permanent inundation on the lives of the remaining residents in Bedono Village, with a focus on their adaptation and resilience methods. The results disclosed that remaining populations have taken active initiation by adopting multiple strategies that include structural prevention measures and nature based solution through mangrove reforestations. As a result based on mangrove assessment using Geographic Information Systems, mangrove cover increased from 1 ha in 2010 to 9.5 ha in 2012. This achievement has provided an alternative income through mangrove ecotourism. Women and multi stakeholder participation have also contributed to the implementation of adaptation strategy. Despite those significant achievements, the adaptation and resilience was challenged by lack of education and awareness towards sea level rise issues and their confounding disasters. The nature-based solution and local wisdom in Bedono Village is an example that is in line with GPDRR UNDRR 2022, the Sendai Framework, and The Bali Agenda for Resilience that ensures a whole-of-society approach to sea-level rise by ensuring that no one is left behind, creating an inclusive environment, and promoting gender.

**Highlights:**

- This study assesses the coping strategy related to the sea level rise inundation;
- The adaptation includes structural prevention measures and nature based solution (NbS);
- NbS has reduced the size of inundated land through mangrove reforestations;
- NbS has provided alternative incomes through mangrove ecotourism;
- Women have been involved within the reconstruction of Bedono Village;
- NbS in Bedono Village is in line with GPDRR UNDRR 2022, the Sendai Framework, and The Bali Agenda for Resilience

**Keywords:** Bedono Village; GPDRR UNDRR 2022; the Bali Agenda for Resilience; the Sendai Framework; sea level rise

## 1. Introduction

### *1.1. GPDRR UNDRR 2022 context*

Natural disasters, such as floods, droughts, earthquakes, and tsunamis, as well as sea level rise, are growing increasingly frequent and intense, increasing the impact on people and communities. Poor planning, poverty, and a variety of other underlying causes

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exacerbate the issue, resulting in insufficient capability to deal with natural hazards and disasters. Action to mitigate risk has gained in prominence on the world agenda, and many consider it as critical to safeguarding sustainable development initiatives and achieving the SDGs.

The 2019 Global Assessment Report on Disaster Risk Reduction (UNDRR) emphasizes the need and urgency of dealing with those natural disasters mentioned before and other systemic risks by taking an interconnected and pluralistic approach to risk understanding. Because the environment interacts and intersects with everything we do, many of these systemic hazards can only be avoided by working with nature rather than against it, a concept known as nature-based solutions. While the term "nature-based solution" is new, managing natural resources and enhancing the flow of ecosystem services for disaster risk reduction is not (UNDRR 2021).

The seventh session of the United Nations Global Platform on Disaster Risk Reduction 2022 (GP2022) was held in Bali, Indonesia from 23 to 28 May 2022. GP2022 emphasized the importance of a whole-of-society approach to disaster risk reduction, ensuring that no one is left behind. In order to create an inclusive environment, the Global Platform highlighted the significance of international solidarity and cooperation, as well as approaches to address underlying risk drivers both locally and globally.

### *1.2. Sendai Framework context*

The Sendai Framework plans to accomplish the significant decrease of calamity endangerment and misfortunes in lives, jobs, and wellbeing and in the financial, physical, social, and ecological resources of people, organizations, networks, and nations throughout the next 15 years. The structure applies to the gamble of limited scope and huge scope, continuous and rare, abrupt and slow-beginning calamities, brought about by normal or synthetic dangers as well as related natural, innovative, and organic perils and dangers. It means directing the multi-danger board of catastrophe risk being developed at all levels as well as inside and across all areas. The Framework was embraced at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, on March 18, 2015 (https://www.rcrc-resilience-southeastasia.org).

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks include (i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience and; (iv) Enhancing disaster preparedness for effective response, and to build back better principle in recovery, rehabilitation and reconstruction (UNDRR 2021).

### *1.3. Global sea level rise threats*

Sea level rise followed by coastal flooding is a climate change induced natural phenomenon caused by an overflow of water in a drainage system, which can cause inundation as well as other negative effects and losses. According to McGranahan et al. 2007, 10% of the world's population or equals 634 million people are populating the low-lying coastal regions within 10 meters of sea level. Those populations are concentrated in 17 or equals 56% of the world's 30 largest cities consisting American continent includes New York, European continent includes London, and most of them are in Asian continent includes Jakarta, Indonesia, Bangkok, Thailand , Mumbai, India, and Shanghai, China.

Many Asian cities' populations will likely continue to grow as ports and labor forces expand to keep up with economic globalization and increased shipping traffic. From 1980 to 2003, the population in 672 coastal counties of the United States' increased from 120 million to 153 million or equals 53 percent of the total populations. While within 5 year, it is expected the population rises from 153 to 160 according to Crossett et al. (2004). Coastal counties in the United States made up 23 of the 25 most densely populated counties in 2003. Rising sea level, in addition to inundating low-lying coastal areas, increases the

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coastal regions are vulnerable to flooding caused by storm surges, tsunamis, and extreme astronomic tides and recently environmental changes through climate change that leads to global warming.

At global level and since the last glacial maximum about 20,000 years ago, sea level has risen approximately 120 m (Fairbanks 1989), and it came to a near halt 2000 to 3000 years ago, when the rate of sea level rise slowed from 0.1 to 0.2 mm/year (Lambeck & Bard 2000). Global warming has resulted in ocean thermal expansion and a net influx of water from melting glaciers. Tide gauge records and other sea-level proxy data show that sea level rose by 195 mm between 1870 and 2004, with an acceleration of 0.013 +/ 0.006 mm/year and an average rate of rise of 1.7 +/- 0.3 mm/year (Church & White 2006). According to 177 tide gauge station data collected from 1948 to 2002 period, Holgate & Woodworth (2004) projected a sea level rise rate of 1.7 +/− 0.9 mm/year, related to a cumulative rise of 9.2 cm +/−. The most current records of sea-level change include of altimetry data from TOPEX/Poseidon and Jason satellites (Nerem & Mitchum 2001) confirms a sea level rise rate of 3.1 +/− 0.7 mm/year (Cazenave & Nerem 2004, Leuliette et al. 2004) for a 10-year period measured from 1993 to 2003.

Climate change induced sea level rise disaster is also observed in Indonesia. Based on a recent study (Sofian 2010), the coastal areas in Indonesia are prone to sea level rise. These phenomena have resulted from global warming-induced melting of glaciers and ice caps (Bamber 2001, Lythe 2001, Rignot 2006) that lead to an expansion of seawater volume ranging from 0.2 to 0.4 m per $^{0}$C of temperature rise. The sea-level rise in Indonesia's coastal areas ranges from 0 to 60 cm. While the sea level rise in Central Java is 30 cm and causes flooding of between 0 m and 4 m height. This disaster is becoming imminent since 65% of Indonesians living in coastal areas and leads coastal livelihoods are extremely susceptible to climate change (Nurzaman et al. 2020).

*1.4. Sea level rise threats in Indonesia*

Coping to this condition, coastal inhabitants in Indonesia have adapted by implementing several adaptation strategies. Those adaptations include adapted with the sea level rise whether with or without actions to adapt with sea level rise with 20-50 cm inundation as observed in Bandengan Village (Jumatiningrum & Indrayati 2021) and Tambak Lorok Village, Central Java (Shabrina 2018). Some observed actions include implementing physical constructions of their houses by elevating the houses and dam constructions. Another adaptive resilience strategy was by changing the livelihood. According to Amin et al. (2016), an impacted fisherman community in Tambak Mulyo Village, Central Java has shifted their livelihood from catching fish to oyster farming in inundated land due to sea flood rise.

Since 1995, coastal flooding has happened in Bedono village (Setyowati et al. 2017), sized at 551 ha on the Demak coast. Since then, coastal flooding has caused multiple cascading hazards and various compounding disaster events. Sea level rise has resulted in frequent and permanent coastal flooding, coastal abrasion, and coastline retreat (Prayogo 2015). Coastal abrasion has happened since 2017. As a result, the size of coastal flooding in Bedono was 110 ha and the size of coastal abrasion was 325 ha. The annual reduction of coastline retreat in Bedono was 550 m/year. The water height in the flooding area ranged from 40 to 60 cm. This long-term disaster, which has been ongoing since 1995, has displaced 78% of the Bedono people. Grounded from this situation, the research aims to assess and evaluate the decadal resilience of coastal communities through collective resilience assessment and a bottom-up approach at the community level. The research aims to assess the causal factors and impacts of sea level rise, measure the level of adaptation and resilience, identify factors that contribute to sea level rise and community adaptation and resilience, and engage both local communities and government in participatory planning and action.

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## 2. Context of the study area and people

### *2.1. Study area*

Bedono Village is one of the villages in Demak Coast, which is located in the Northern part of the center of Central Java, Indonesia (Figure 1). The area of Bedono Village is geographically located at latitude coordinates 06°55'40" S - 06°53'30" S and longitude coordinates 110°28'0" E - 110°30'30" E. This village is bordered directly with Java Sea. Demak coast has a coastline with length of 25.02 km. Demak Coast elevation is mostly 0 m due to its location near the sea. The highest point reached 100 m is located in the hilly areas in the Eastern parts. The land use compositions of Bedono Village were dominated by fish ponds (80.9%) and followed by paddy fields (6.73%), settlements (10.32%), and road networks (2.33%).

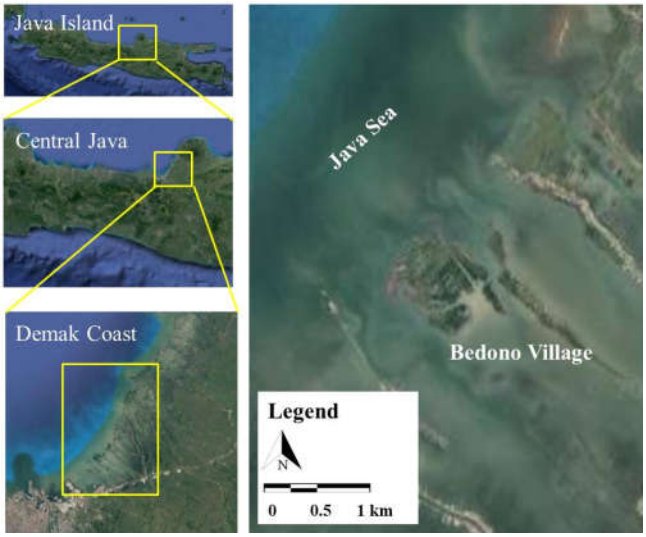


**Figure 1.** Location map of the study area in Bedono Village, Demak Coast located in the Northern part of the center of Central Java, Indonesia (image source: Google Earth).

### *2.2. People in the study area*

The livelihoods of the residents of Bedono Village were dominated by working as farm laborers, as many as 812 people (23.76%), followed by working as fishermen, reaching 702 people (20.54%), construction workers, equaling 614 people (17.97%), industrial workers, equaling 576 people (16.86%), traders (445 people or 13.02%), farm owners, equaling 201 people (5.88%), transportation workers (64 people or 1.87%), and entrepreneurs, equaling 0.09%. The livelihoods in Bedono Village, which mostly consisted of people working in informal sectors, were related to their educational background.

The residents of Bedono Village have a low level of education. The population of Bedono Village who did not finish elementary school was 549 people, or about 14%, while those who continued their education up to college level were 21 people, or only 1%. The levels of education that are most widely taken are junior high school and senior high school education, with 852 people (22%) and 823 people (21%).

### *2.3. Sea level rises in Bedono village*

The sea level rise phenomenon in Bedono Village that leads to the permanent flood is caused by a combination of many factors, including natural and anthropogenic causes, including the establishment of fish ponds. The existence of massive fish ponds is related to the extensive mangrove deforestation. The historical time line and dynamic of sea level rises, land use changes, and their impact on communities can be seen in Table 1 below.

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**Table 1.** The historical time line and dynamic of sea level rises, land use changes, and their impact in Bedono Village.

| Year | Remarks |
|---|---|
| 1990 | Mangrove deforestation to establish fish ponds |
| 1997 | Mangrove reforestation |
| 1999 | Displacement of 266 families |
| 2000 | 5.26 km$^2$ was flooded and 1.5 km of coastline has altered due to the flood |
| 2001 | Sea level rise inundated 208.65 ha |
| 2006 | Sea level rise inundated 690.9 ha |
| 2007 | Construction of dam |
| 2009 | Reforestation increased mangrove areas from 22.41 ha in 2004 to 43.03 ha in 2009 |

## 3. Methodology

In order to assess sea level rise disaster impacts and collective community resilience in Bedono Village toward disaster, this paper uses a mixed method approach. It draws upon information and data collected from primary and secondary sources (Sufri et al. 2019, Sakamoto et al. 2020) during the study. As the paper is focused on issues and empirical evidences of disaster impacts, adaptation strategy and resilience, it analyses data and information available. In addition to the above-mentioned survey data, reports and publications from various scholars and government agencies have also been used to understand the formulation of various facts, products, and policies. Data issued by statistical agencies, regulations and policies issued by local governments from provincial to district levels were also analyzed. A literature review was conducted to understand the intertwined issues related to disaster impacts, adaptation strategy, and resilience documented in Bedono Village. The second method is the mangrove assessment. This method is implemented since the sea level rise disaster in Bedono Village was related with the presences of mangrove deforestation and reforestation activities, and land use changes.

### *3.1. Literature assessment*

The literature assessment presented in this study includes some of the general methodological guidelines set for literature reviews started with reviewing existing secondary evidences in the form of prior assessments, documents, and other reports (Fakhruddin et al. 2019, Khattri 2021). This review steps include establishing question classification and continuing with the scanning and selecting of papers against the inclusion and exclusion standards. The exclusion standards include non-academic literature and non-scientific information ranging from personal opinions, blogs, tweets, and Wikipedia. While, for literature incorporating inclusion standards, we conducted a search of the Google Scholar database using several primary keywords, including "Bedono", "disaster", and "sea level rise", as for identifying and extracting reports, government regulations and laws, and academic literature focusing on disasters associated with the sea level rise disaster in Bedono.

### *3.2. Mangrove and land use change assessment*

This assessment is aimed to provide empirical evidences of mangrove deforestation and reforestation in Bedono. For this purpose, mangrove cover and its mapping were observed using LandSat 8 satellite imagery with 12 bands (bands 1 to 12) which were then analyzed by remote sensing and Geographic Information Systems (GIS). LandSat 8 satellite imagery will classify which parts of the restoration area are mangroves and which are not by remote sensing. Then GIS will classify the satellite image and separate which objects are mangroves and which are settlements and ponds. The measurement results are the area of mangroves and those that are not (settlement, ponds) which are expressed in km$^2$.

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## 4 Results

### *4.1. Impacts and causes of disasters*

Sea level rise and flooding have caused significant impacts on communities and the environment. Although there were no casualties, flooding has displaced 173 families out of 220 families. Regarding the economic impacts, the loss of primary revenues from fish ponds and paddy fields equals 12 billion Indonesian rupiahs per year. Despite that, there is an increase in daily living costs since basic needs should be imported from other villages. Social aspects were also impacted. Regarding the social issue, the flooding has created potential horizontal conflicts among community members to gain access to the water supply. Flooding has had a significant impact on the lands that were previously paddy fields. As a result, an inundation of paddy fields has significantly changed the livelihood of the community that had previously been farmers. As a result, residents of Bedono have experienced a cultural shock, especially the farmer community, whose lifestyle has been changed from farming to maritime life. Besides that, mental health cases have been reported in a community that has lost its land.

Because it is a coastal area, sea level rise and flooding have a greater impact on the landscape and its ecosystems than on other types of land. The environmental impacts of flooding on terrestrial ecosystems include a 66% reduction in fish ponds and paddy fields. The presence of saltwater flooding has resulted in saltwater intrusion and a decrease in freshwater/water table levels. The natural ecosystems are not the only aspects that have been damaged by the floods. Bedono was previously a village, with the development of various infrastructures and properties. Then the flooding has greater consequences and impacts on critical services, infrastructure, and businesses. Sunken houses accounted for 127 units of damage in 2009 and 2 units in 2013 (Asiyah et al. 2015). Several infrastructure damages were observed due to corrosion. At the same time, flooding has expanded and disrupted the provincial road network and logistics. This has caused loss of vital public facilities, including schools and community health facilities. To sum up, the key sectors impacted are the revenue loss from fish farming and saltwater intrusion, which causes loss of access to the water supply. About 42% of the villages are considered most vulnerable to socio-economic impacts (Rudiarto et al. 2016).

Bedono village's vulnerability towards flooding disaster was caused by various variables. Besides natural factors in the form of sea level, the exposure of Bedono to hazard was related to anthropogenic factors. In this village, a natural flood barrier in the form of dense mangroves has been converted into fish ponds (Figure 2). Besides that, populations of Bedono that were dominated by fishermen and fish farmers opted to build their houses close to the beach, and this increased their vulnerabilities. Another vulnerability is related to the capacity of the soil in Bedono to absorb water. The absorption capacity in this village was only 0.015 m/day, and this caused the accumulation of water, which led to flooding. This condition is worsened by the fact that Bedono's residents have low levels of disaster awareness due to a lack of education and literacy about ongoing coastal flooding disasters. The only sources of information were provided and disseminated by the staff of the Fisheries Agency.

### *4.2. Adaptation and resilience toward disasters*

Several steps have been taken towards managing the sea level rise and flooding disasters. Those steps covering legislation/policy/guidelines/safety rules, prevention measures, mitigation measures, preparedness and capacity building measures, and risk analysis and risk communication. Legislation/policy/guidelines/safety rules were initiated by Demak District government and it has issued series of district level legislation to prevent coastal flooding in Demak and Bedono Village. Those policies including:

- Issuance of Demak Mayor Regulation No. 9 of 2016 emphasizing the implementation of coastal flooding disaster management. In general, this regulation aims to provide protection of people from hazard; guarantee the implementation of planned, comprehensive, coordinated disaster management; minimize disaster loss; increase

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capacity building; and community participation and engagement toward disaster management.

- Demak Mayor Regulation No. 12 Year 2016 has been issued providing the guideline for school safety towards coastal flooding. This regulation addresses on the identification of schools that are most prone to coastal flooding. It also provides frameworks and guidelines on how to build a school that is more resistant to flooding.
- Demak Mayor Regulation No. 6 Year 2011 on Demak Land Use Planning for the Period 2011–2031 has been revised and amended to Demak Mayor Regulation No. 1 Year 2020 on Demak Land Use Planning for the Period 2011–2031.This revised regulation has added the conservation of mangroves as a barrier to provide protection against flooding, and land use planning based on strict zonation has been included.

Structural prevention measures have been implemented at a large scale with the support of authority through the construction of sea walls and dams, coastal embankment, and irrigation channels. The wall functions to obstruct the water and channel to irrigate the flood water to the river and back to sea (Rudiarto et al. 2020). Mitigation measures were implemented through a nature based solution by reforestation of remaining Bedono Village lands through mangrove planting equals 1 million seedlings since 2004 (Figure 2). This reforestation aims to trap the sediment using mangrove *Rhizophora* species. The sediment accumulated by mangrove roots can increase the size of land that previously was lost due to land abrasion caused by sea level rise and flooding. Beside that sediment can absorb the accumulated water. So far this nature based solution has significant progress. As a result, mangrove covers were increasing from 1 ha in 2010 to 9.5 ha in 2012. Recently in 2020, mangrove covers have increased 2 folds to 21.4 ha.

Anticipating the expansion of floods, the remaining population in Bedono has implemented some preparedness measures, including elevating the house foundation ranges by 50–100 cm (Figure 3). Simultaneously, the local authorities have prepared an infrastructure that is more adaptable to the flood by increasing the elevation of the road to avoid the flood (Pamungkas 2015, Asrofi et al., 2017, Haloho & Purnaweni 2020).

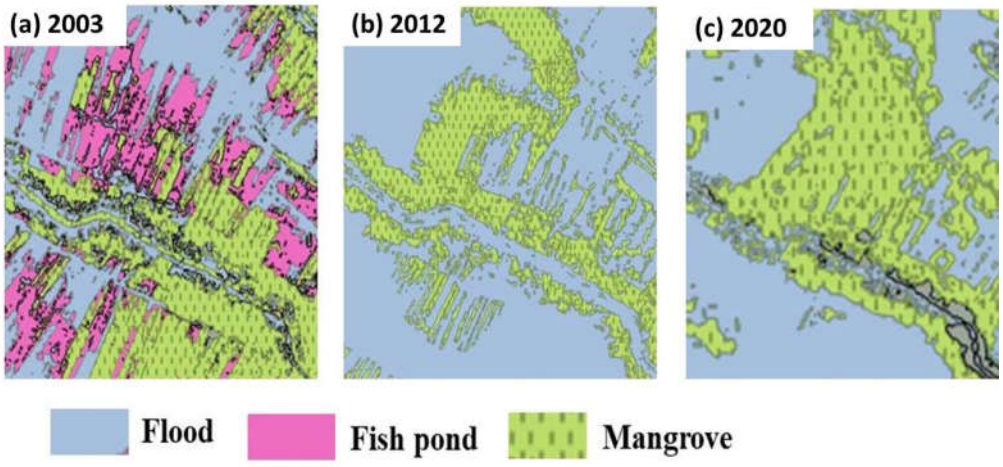


**Figure 2.** In 2003, mangrove deforestation and absence of coastal protection has caused flooding and land abrasion events in Bendono Village (a). In 2020, the size of flooding and abrasion increased and displaced 78% of population. Remaining population started to do mangrove reforestation (n). This resilience has succeeded to provide nature based solution. During this adaptation and recovery events, the remaining population uses the reforested mangrove sites as ecotourism destination to gain alternative incomes (c).

*4.3. Multi stakeholder participations*

Several necessary steps to manage the sea level rise and flooding have been implemented from local to national levels involving multiple stakeholders (Table 2, 3). At local level, in 2015, 48 local residents with 50% were women have participated in construction

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of semipermeable dam. Recently in 2020, as an implementation of mangrove reforestation and education program, 2000 mangrove *Rhizophora* species have been planted. At national level, since 2015, a consortium involving experts from numerous international NGOs and district offices of public works and housing and fishery collaborated with local communities has implemented Hybrid Engineering (HE) technology through Building With Nature Project. This project aims to reduce flood area and simultaneously reclaim the land by increasing land size through sedimentation process. As a result, the land and sediment have reached a height of 57 cm. HE in Bedono was implemented through constructing of sea wall using bamboo and net filled with piles of twigs to strengthen the bamboo wall. Currently the length of HE bamboo sea wall has reached a total length of 750 m and the construction of this sea wall was supported by women participations with 30% of HE voluntary workers were women.

Recent conditions of massive flooding in Bedono Village have received attention at regional and international levels. The disaster was considered as significant case studies representing threats on global wetland ecosystems. As a result, an international NGOs in wetland conservation has committed and funded the mangrove restoration project and ecotourism in Bedono (Figure 3). After 1.5 years, this project has resulted in construction of 250 m mangrove track used for ecotourism, mangrove green belt construction, and livestock cultivation.

**Table 2.** Roles of multiple key stakeholders in Bedono Village.

| Stage | Local authority | Community | Academic | Non Government Organization |
|---|---|---|---|---|
| Pre | Construct the coastal embankment and bamboo wall/ Hybrid Engineering | Help the authority to build the embankment, mangrove planting | Provide technical assistance, training, and research based evidence and baseline data for land use plan and early warning system. | • Provide funding, expertise, and in-kind contributions<br>• Advocate the disaster issue to formulate regulation |
| Disaster response | Ensure the distribution of equipment including boat, water pump | Volunteer to assist the authority to rescue the impacted neighbors | | |
| Post | Facilitate the reconstruction process including renovating the damaged infrastructure | Collaborated with stakeholders to plant mangroves as part of reforestation | Assist the community capacity in recovery stage including on how to:<br>1. develop and manage ecotourism to gain sustainable revenue;<br>2. implement participatory mapping as part of early warning system. | |

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**Table 3.** Implementations of The Bali Agenda for Resilience Indicators (https://www.undrr.org/) and Sendai Framework Priority Areas (UNDRR 2021) in Bedono Village.

| No | Indicators of The Bali Agenda for Resilience | Sendai Framework Priorities | Implementations in Bedono Village |
|---|---|---|---|
| 1 | a "Think Resilience" approach must be applied to all investments and decision making, integrating DRR to ensure a whole-of-government and whole-of-society approach. | (i), (iii) | All investment and decisions to restore the Bedono Village have involved whole community members based on resilience principles. |
| 2 | DRR must be integrated at the core of development and finance policies, legislation, and plans to achieve the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs); | (ii) | The local government has exhibited support through the issuances of several regulations to safeguard the remaining mangrove ecosystem and village. |
| 3 | The development of multi-hazard early warning systems (MHEWS) must be inclusive of communities most at risk with adequate capacity to act on early warnings, and ensure better availability, quality, and sharing of data, financial resources, and effective governance and coordination arrangements to fully implement the call by the UN Secretary-General to ensure every person on Earth is protected by early warning systems (EWS) by 2027; | | Unfortunately, there is no multi-hazard early warning system (MHEWS) among communities present in Bedono Village. In fact, his MHEWS continue to rely on traditional methods rather than advanced MHEWS technologies. |
| 4 | Recovery and reconstruction are most successful when they are community-driven and support existing local structures and resilience-building mechanisms, while addressing barriers to inclusivity through gender-responsive and human rights-based approaches; | (iii), (iv) | Recovery and reconstruction of Bedono Villages were supported and driven by the whole community based on inclusivity and gender equity, with the participation of women equaling 30%. |
| 5 | Ecosystems should be considered as critical infrastructure and recognized for their basic services, bringing environmental, socio-economic, and cultural benefits | (i), (iv) | The ecosystem, in particular mangrove ecosystems, has been a mainstay for restoring livelihoods through the ecotourism mechanism that can yield revenues. |

The Sendai Framework for Disaster Risk Reduction Priority Areas: (i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience and; (iv) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

*4.4. Key gaps and challenges*

Since the beginning of the disaster, the gaps and challenges have been related to at least 2 major issues. The first issue is awareness, and the second is regarding the enforcement issues. Due to community awareness, Bedono Village is becoming more prone to sea level rise and coastal flooding. Lack of awareness is due to a lack of risk perception and communication delivered to the community. The residents of Bedono Village are illiterate about the hazards and risks of living on the coast.

At the national level, there is a regulation that restricts the conversion of intact mangroves and also limits settlement construction near that coast. This regulation was made

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with the aim of ensuring the development was implemented in a sustainable way and preventing flooding. In fact, the challenges were related to the law enforcement in the field to ensure compliance with that regulation. In this regard, there was no monitoring and even no evaluation activities to ensure the development of Bedono followed and complied with the regulation.

Flood disaster management requires some capacity supported by financial support. The majority of those affected were farmers who lacked knowledge of how to build flood-resistant houses and elevate them. Some marginalized and low-income farmers also did not have sufficient funding to renovate their houses. In Bedono, there was no important or critical infrastructure. As a result, the resources allocated for disaster management here were not prioritized. At the same time, district authorities have a limited available budget to support the flood disaster management in Bedono. The success of post-disaster recovery requires transboundary policies and regulations in the form of revised land use plans. The main difficulties were that the proposed post-disaster land use plan for Bedono was contradicted by existing land use planning, which could not be changed. Then the post-disaster plan for Bedono should follow the existing large-scale land use plan that was not suitable for Bedono.


**Figure 3.** Situations in impacted Bedono Village, from prevention and mitigation (top row) to preparedness, recovery and resilience from disaster through mangrove ecotourism to provide alternative incomes for impacted communities (bottom row).

*4.5. Lessons learnt and recommendations*

In the context of policy, the local authorities have learned that the former policy has limitations and does not adapt to the current situation. As a result, the previous Demak Mayor Regulation No. 6 Year 2011 on Demak Land Use Planning for the Period 2011–2031 was revised and resulted in Demak Mayor Regulation No. 1 Year 2020 on Demak Land Use Planning for the Period 2011–2031.This revised regulation has learned from previous regulations regarding the importance of mangroves as a barrier to providing protection against flooding. In this current regulation, land use planning based on strict zonation has been included (Magfiroh 2018).

After the disaster and supported by authorities and community-based organizations (NGO), the remaining population in Bedono has learned and adapted to the current situation. They learned the importance of mangroves (Wacano et al. 2013) and were motivated to do reforestation. The disaster in Bedono has also had a ripple effect. Witnessing what happened to Bedono, the neighboring villages are also aware that the sea level rise and coastal flooding are real threats. Neighboring villages have also realized the negative

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effects of mangrove deforestation. Now they have started to limit the mangrove conversion and are starting to do mangrove plantations.

Aside from community-based mangrove planting and land rehabilitation, ecotourism is one of the best practices used by the remaining population to survive. Driven by the need to fulfill daily necessities, the impacted population has started to gain revenues from alternative and sustainable resources. In this regard, they have developed mangrove reforestation as an ecotourism destination.

To sustain the resilience of Bedono Village, several recommendations have been formulated covering several issues, including ecological systems, engineering and infrastructure systems, social-economy systems, and risk communication system recommendations. Those recommendations are:

- Ecological system recommendation:

-to process and use saltwater as a freshwater source and alternative water supply through the desalination process;

-to establish a mangrove nursery as the seedling bank for mangrove reforestation.

- Engineering and infrastructure system recommendation:

-to increase local capacity and skills in doing some engineering work, including how to elevate the house;

-to integrate land use planning with disaster indicators.

- Social-economy system recommendation:

-to establish a specific Coastal Village-Owned Enterprise to support the development of alternative revenue sources from mangrove forests through ecotourism;

-to establish a village community emergency response team.

- Risk communication system recommendation:

-to integrate scientific knowledge with traditional knowledge and indigenous practices, and establish communication channels with scientific technicians;

-to communicate the coastal disasters, mainly technical terms in their native language, to debottleneck the communication barrier.

## 5. Conclusion

The finding of this study shows the example and complexity of sea level rise inundation disasters on a village. The observations show despite most residents have abandoned the villages, small portions of the residents have survived by adapting to the sea level rises. The survived community took active initiation by adopting multiple strategies that include structural prevention measures and nature based solution. So far this nature based solution has significant progress. As a result, mangrove covers were increasing from 1 ha in 2010 to 9.5 ha in 2012. Recently in 2020, mangrove covers have increased 2 folds to 21.4 ha. The success of implemented adaptation strategy was supported by equal women participation and multi stakeholder participations. The nature-based solution and local wisdom in Bedono Village is an example that is in line with GPDRR UNDRR 2022, the Sendai Framework, and The Bali Agenda for Resilience that ensures a whole-of-society approach to sea-level rise by ensuring that no one is left behind, creating an inclusive environment, and promoting gender. Despite those achievements, the adaptation strategy was still challenged by lack of education and awareness towards sea level rise disasters.

## References

1. Amin, C., Sukamdi, Rijanta, 2016. Fisherman adaptation strategies to coastal flood in Tambak Mulyo Village, Tanjung Mas, Semarang. The 3rd University Research Colloquium.
2. Asiyah, S., Rindarjono, M. G., Muryani, C., 2015. Settlement change analysis and settlement characteristics slums due to abrasion and inundation in the coastal district of Sayung Demak District 2003 – 2013. Jurnal GeoEco. 1(1), 83 – 100.
3. Asrofi, A., Ritohardoyo, S., Hadmoko, D., 2017. Community adaptation towards coastal floods in Bedono Village. Jurnal Ketahanan Nasional. 23(2), 125-144.

4. Bamber J. L., Layberry, R. L., Gogenini, S. P., 2001. A new ice thickness and bedrock data set for the greenland ice sheet. JGR Atmospheres. 106(D24), 33773-33780. DOI: 10.1029/2001JD900054.
5. Cazenave, A., Nerem, R.S., 2004. Present-day sea level change: observations and causes. Rev. Geophys. 42, 20. DOI: 10.1023/A%3A1026238318585.
6. Church, J.A., White, N.J., 2006. A 20th century acceleration in global sea-level rise. Geophys. Res. Lett. 33:L01602, DOI: 10.1029/2005GL024826.
7. Crossett, K.M., Culliton, T.J., Wiley, P.C., Goodspeed,T.R., 2004. Population trends along the coastal United States: 1980–2008.Coast. Trends Rep. Ser., NOAA, Natl. Ocean Serv. Manag. Budg. Off., Spec. Proj., Silver Spring, MD.
8. Demak Mayor Regulation No. 6 Year 2011 on Land Use Planning of Demak for Period of 2011-2031.
9. Demak Mayor Regulation No. 9 Year 2016 Implementation of Coastal Flooding Disaster Management.
10. Demak Mayor Regulation No. 12 Year 2016 Guideline for School Safety Towards Coastal Flooding in Demak.
11. Demak Mayor Regulation No. 1 Year 2020 on Land Use Planning of Demak for Period of 2011-2031.
12. Fakhruddin, B., reinen-hamill, R., Robertson, R., 2019. Extent and evaluation of vulnerability for disaster risk reduction of urban Nuku'alofa, Tonga. Progress in Disaster Science. 2. 100017. DOI: 10.1016/j.pdisas.2019.100017.
13. Haloho, E. F., Purnaweni, H., 2020. Adaptation of Bedono Village community to rob flood in Sayung Kecamatan, Demak District, Central Java. Journal of Public Policy and Management Review.
14. Holgate, S.J., Woodworth, P.L., 2004. Evidence for enhanced coastal sea level rise during the 1990s. Geophys. Res. Lett. 31, 4.
15. Jumatiningrum, N., Indrayati, A., 2021. Adaptation strategy of the Bandengan Village community, North Pekalongan District in facing tidal floods. Edu Geography. 9(2).
16. Kattri, M.B., 2021. Differential vulnerability and resilience of earthquake: A case of displaced Tamangs of Tiru and Gogane villages of Central Nepal. Progress in Disaster Science. 12.
17. Lambeck, K., Bard, E., 2000. Sea-level change along the French Mediterranean coast for the past 30000 years. Earth Planet. Sci. Lett. 175, 203–22. DOI:10.1016/S0012-821X(99)00289-7.
18. Leuliette, E.W., Nerem, R.S., Mitchum, G.T., 2004. Calibration of TOPEX/Poseidon and Jason altimeter data to construct a continuous record. Mar. Geod. 27, 79–94. DOI: 10.1080/01490410490465193.
19. Lythe, B. Matthew, Vaughan, D. G., 2001. BEDMAP: A new ice thickness and subglacial topographic model of Antarctica. J. Geo. Res, 106(B6), 11335–11351. DOI: 0.1029/2000JB900449.
20. Magfiroh, L., 2018. District Government Policy Analysis In Handling Coastal Flood Rob In Demak District. Thesis, Universitas Wahid Hasyim, Semarang.
21. McGranahan, D.A., Balk, D., Anderson, B., 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environ. Urban. 19, 17–39.
22. Nerem, R.S., Mitchum, G.T. , 2001. Observation of sea level change from satellite altimetry. In Sea Level Rise, ed. BC Douglas, MS Kearney, SP Leatherman, pp. 121–64. San Diego: Academic.
23. Nugroho, H., Indriastuti, A.K., Yulipriyono, E.K., Wibowo, M.A., Hermawan, F., 2020. Erosion management in Bedono Village. Jurnal Pasopati, 2(1).
24. Nurzaman, A., Shaw, R., Roychansyah, M., 2020. Measuring community resilience against coastal hazards: Case study in Baron Beach, Gunungkidul Regency. Progress in Disaster Science. 5. 100067. DOI: 10.1016/j.pdisas.2020.100067.
25. Pamungkas, C., 2011. Community Response And Anticipation Towards Coastal Floods In Demak District. Thesis. State University Semarang, Semarang.
26. Prayogo, T., 2015. Analysis of changes in the coastal line of Semarang and its surroundings based on multitemporal Landsat satellite image. Prosiding Pertemuan Ilmiah Tahunan XX 2015.
27. Rignot, E., Kanagaratnam, P., 2006. Changes in the velocity structure of the Greenland ice sheet. Science. 311(5763), 986-990.
28. Rudiarto, I., Pamungkas, D., Annisa, H., Adam, K., 2016. Socio-economic vulnerability towards coastal flooding in Demak Coast. Jurnal Wilayah dan Lingkungan. 4(3), 153-170.
29. Rudiarto, I., Rengganis, H., Sarasadi, A., Caesar, E., 2020. The effectiveness of strategy adaptations on tidal flood in the coastal areas of Sayung, Demak, Central Java, Indonesia. IOP Conference Series: Earth and Environmental Science, 448, 012090. DOI: 10.1088/1755-1315/448/1/012090.
30. Sakamoto, M., Sasaki, D., Ono, Y., Makino, Y., Kodama, E., 2020. Implementation of evacuation measures during natural disasters under conditions of the novel coronavirus (COVID-19) pandemic based on a review of previous responses to complex disasters in Japan. Progress in Disaster Science. 8. 100127. DOI: 10.1016/j.pdisas.2020.100127.
31. Setyowati, D., Amin, M., Astuti, T., Ishartiwi, 2017. Community efforts for adaptation and anticipate to flood tide (ROB) in Bedono Village, District Sayung Demak, Central Java, Indonesia. Man in India, 97, 241-252.
32. Shabrina, C., 2018. Community Adaptation Strategies To Face Flood Tide In Tambak Lorok Area, Semarang Utara. Thesis. Gadjah Mada University, Yogyakarta.
33. Sofian, A., 2010. Scientific Basis: Analysis and Projection Sea Level Rise and Extreme Weather Event Report. Indonesia Climate Change Sectoral Roadmap – ICCSR.
34. Sufri, S., Dwirahmadi, F., Phung, D., Rutherford, S., 2019. A systematic review of Community Engagement (CE) in Disaster Early Warning Systems (EWSs). Progress in Disaster Science. 5. 100058. 10.1016/j.pdisas.2019.100058.
35. UNDRR. 2021. WORDS INTO ACTION: Engaging for resilience in support of the Sendai Framework
36. for Disaster Risk Reduction 2015-2030.

 doi:10.20944/preprints202206.0161.v1

37. Wacano, D., Rif'an, A. A., Yuniastuti, E., Daulay, R. W., Marfai, M. A., 2013. Adaptasi masyarakat pesisir Kabupaten Demak dalam menghadapi perubahan iklim dan bencana wilayah kepesisiran. In Buku Seri Bunga Rampai Pengelolaan Lingkungan Zamrud Khatulistiwa (pp. 20-33). Percetakan Kanisius Yogyakarta.

**Website sources**

https://www.undrr.org/publication/co-chairs-summary-bali-agenda-resilience

https://www.undrr.org/sites/default/files/2021-10/Nature-based%20Solutions%20for%20DRR_2021_06_24_0.pdf

https://www.rcrc-resilience-southeastasia.org/document/sendai-framework-for-disaster-risk-reduction-2015-2030/