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# A Toward Sustainable Built Environment: A Gender-Eco Friendly Master Plan of A Sinking Village for Climate Change Adaptation

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**Abstract** Demak Regency is one of several cities that are submerged by tidal flooding disasters caused by climate change, especially in Sriwulan Village, Sayung District, which threatens the sustainable built environment and also the women in the village. Even though the built environment has been disturbed by climate change, women can adapt and take the initiative during disaster events, including taking the place of their jobless husbands as breadwinners during the Covid-19 pandemic. A gender-responsive village master plan could become a crucial issue in village development, especially for the ones impacted by disasters. Therefore, this research is located in Sriwulan village, Sayung District, Demak Regency which wants to create a gender eco-friendly master plan for Sriwulan village for a sustainable built environment. A descriptive-qualitative method was conducted to produce a gender eco-friendly Sriwulan village's master plan. The result found a rapid increase in tidal flooding inundation and level in Sriwulan village. It was also reported that women have a limited role in tidal flooding disaster risk reduction and adaptation because of insufficient information, training, and workshop about climate change, disaster risk reduction, and adaptation. In conclusion, women should be given the opportunity as an actor in leading the community to cope with the climate change impact for a better future by increasing their capability and fair knowledge. In the future,

village life will be prolonged by the "Gender Eco-Friendly Master Plan for Sustainable Built Environment of Sriwulan Village" which will change Sriwulan to a prospective Eco-Tourism Village.

**Keywords** Sustainable, Built Environment, Gender, Eco-Friendly, Master Plan, Climate Change, Adaptation

## **1. Introduction**

A study conducted by the Kompas team [1] published a very shocking analysis in the middle of August 2021 about the prediction of coastal area sinking in Indonesia, from Sabang (the eastern part of Indonesia) to Merauke (the western part of Indonesia). It was reported that there are 119 cities and regencies in Indonesia were predicted submerged by tidal flooding.

Climate change has changed the world, that causes seawater depth increase, climate extremes, drought [2,3], and flooding and also tidal flooding, which happened periodically in the north Java coastal area. Several investigations, studies, and research reported that in the last 3 decades, the coastal area has been continuously submerged by tidal flooding (called 'rob' in the Javanese

language) caused by climate change. The coastal line along Java Island has changed and reduced by several kilometers including Demak Regency which is located in Central Java Province in Indonesia, especially in Sayung District and Sriwulan village. The worst impact of sea erosion happened in Indonesia was found in Sriwulan village which has lost its area of 2.116,54 ha for 20 years and a 5 km reduction of its coastal line since 1994 [4]. The abrasion rate of Sayung District was found as 82% and the accretion was 18% [5].

Several studies of the impact of tidal flooding in Sriwulan village and the disaster risk reduction to cope with the problem were also reported by authors [6,7] as well as several investigations that have been conducted in that area [8-10,17-19]. Some good lessons come from the case of tidal flooding in Semarang that affected the northern coastal area of the city, including Tambak Lorok settlement [20], Panggung Lor Sub-District [7], and several Sub-Districts in Tugu District [21]. The case in Tambak Lorok settlement was to examine community vulnerability and to build adaptation for keeping the buildings and public facilities in safety, while the Panggung Lor Sub-District case was about increasing resiliency and adaptation by community-based disaster risk reduction. In Tugu District, resiliency has been grown by developing mangroves as a natural barrier. However, the tidal flooding caused so big damage to the mangrove forest that an urgent effort has to conduct to save the District from the hazard of tidal flooding.

In tidal flooding-prone areas, the built environment must be both influenced and also makes influenced by its surroundings. People create or modify the built environment which consists of buildings and living spaces. Wider than the definition, the built environment includes the infrastructural elements such as waste management, transportation, and utility transmission systems that serve the building space [22]. However, it is a fact that built environments such as buildings and infrastructure contribute to global warming which is the main issue of climate change. There is no doubt that the built environment has a significant environmental footprint as the RIBA report [23] that the growth of buildings is very incredible since the 255 billion m<sup>2</sup> of buildings in the world today which increases to around 5.5 billion m<sup>2</sup> every year will still exist in 2050. A good approach and solution to cope with the environmental footprint built environment are to make better use of existing buildings that will reduce the demand for new construction, minimize the negative environmental impact of new buildings, and make the best decisions that put the long-term health with financial concern [23]. Hence, there is no doubt to evaluate the built environment in terms of sustainability that complies with the needs and requirements of future generations [22]. For instance, it is important to build zero-carbon buildings, reduce embodied carbon [24], implement built environment adaptation to climate change, and meet beyond the minimum criteria in regulation [25]. In

adaptation urban planning, we need to enhance the physical protection of urban assets from extreme weather as climate change impacts. The authorities have to build protection against sea level rise and flooding i.e. seawalls and pumps and also ecological solutions i.e. wetlands and mangrove forests [26]. A sustainable built environment is not only about the buildings but also about the infrastructure and environment. Speaking about the 'sinking village', Sriwulan village, a built environment will become a big portrait of sustainable living space that will not sink because they want to change their face to become a prospective eco-tourism village like others, especially after the Covid-19 pandemic [27]. Therefore, the eco-tourism village of Sriwulan is an eco-friendly built environment that is designed to have little or no damaging effect on the environment through a responsive gender adaptation to climate change.

The built environment has been disturbed by climate change; hence, an adaptation of tidal flooding-prone areas should be implemented to reduce the hazard and to protect the vulnerable ones, the women and children. Every event of a disaster will strongly impact women, which may become a gender inequality issue. Climate change give a deep impact on vulnerable groups in society i.e. women, children, elderly people, disabled people, indigenous people, and local communities, and also people in coastal areas, urban and rural areas [28,29]. To anticipate the impact of climate change, it is necessary to implement climate change adaptation. However, adaptation to climate change disasters is not neutral to gender, since women and men have different capacities and contributions in adaptation as well as their different needs. On one side, climate change disaster makes women's discrimination and gender inequality become worse, but on another side, the situation will be harder because of the limited role of women as a decision maker in climate change issues [29]. Since women face unfair situations and also double burden during disaster events as has happened in tidal flooding-prone areas, the presence of the government is very important.

The role of government and community to reduce the disaster and implement policy in a wise and 'smart' way is necessary. There is no doubt that a responsive gender climate change adaptation is very crucial as well as gender mainstreaming. United Nations Economic and Social Council (ECOSOC) on July 1997 emphasized that we should implement gender mainstreaming as a process of assessing the implications for women's and men's planned actions, including legislation, policies, and programs [30,31].

The gender-eco-friendly term has been elaborated in terms of gender, women, and environment, by several Ministries and Agencies in Indonesia with Ministerial Regulations and other Regulations such as the Ministry of Women Empowerment and Children Protection, the Ministry of Environment and Forestry, and also the Ministry of Finance, National Disaster Mitigation Agency

[28,29,32]. A gender-responsive village master plan could become a crucial issue in village development, especially for the ones that suffered from the disasters. The issuance of Law No. 6/2014 has shown that Indonesia's government wants to strengthen village development by constructing the village authority that has the responsibility for village development, empowering village community development through their initiatives, rights origin, and village customs [33]. It should be noted that Law No. 6/2014 Indonesia is very gender responsive that involves women's participation in village development as mandatory. Specifically, in village development terms, another regulation of Government Regulation (PP) No. 43 of 2014 on Village Article 121 paragraph (2) has the obvious statement that village development activities must be determined based on gender justice. Instead of the responsive gender law and regulation about village development, the Presidential Instruction Number 9 of 2000 assigned all the Ministers, Heads of Non-Ministerial Institutions, Governors, and Regents/Mayors to involve and implement the gender mainstreaming in order to carry out planning, implementation, monitoring and evaluation of national development policies and programs with a

gender perspective in accordance with the field of duties and functions, as well as their respective powers [32]. Therefore, this research proposed the term "a gender eco-friendly" master plan for village development that can be defined as an act of gender mainstreaming in coping with the climate change impact, especially in Sriwulan village. Obviously, the "gender-eco-friendly" master plan is conducted by an eco-friendly master plan with gender consideration to climate change adaptation.

The people in Sriwulan village who are now hopeless about their sinking village need a change and a better future for their living space. We could promote an adaptation to climate change for a sustainable built environment in Sriwulan village by producing a gender eco-friendly master plan for the future of the village. Hence, this research wants to create a gender eco-friendly master plan for Sriwulan village for a sustainable built environment. The gender-eco-friendly master plan of Sriwulan village become a great hope to the most vulnerable groups in the event of a disaster, the women and children, that in the middle of a tidal flooding disaster, they will have a safer and more comfortable place to live.

## 2. Method of Research

### 2.1. Research Sites



**Figure 1.** Satellite image of Sriwulan village in Sayung District, Demak Regency, Central Java Province, Indonesia, on February 2022 by Google Earth

The research was located in Sriwulan village, Sayung District, Demak Regency, Central Java Province in Indonesia. Demak Regency has an area of 897,43 km<sup>2</sup> that consists of 14 Districts [34]. One of those districts is Sayung District which has an area of 78.80 km<sup>2</sup> and comprises 20 villages, one of them is Sriwulan village. As shown in Figure 1, Sriwulan village located next to the Java Sea, lay on 6 ° 55' - 6 ° 56' East Longitude and 110 ° 27' - 110 ° 29' North Latitude. The Sriwulan village has an area of 4.02 km<sup>2</sup> with topography about 0-3 meters above the sea level which makes the village prone to tidal flooding [35]. It was reported Sriwulan village has 7 hamlets, 8 neighbourhood communities of Rukun Warga (RW), and

76 neighbourhood communities of Rukun Tetangga (RT) [36].

The demographic of Sriwulan village is reported by the Central Java information system through the website of <https://sidesa.jatengprov.go.id/pemkab/kependudukandes/33.21.04.2011> which is based on the integrated data of Demographic Administration Information System in 2020 as follows. The population of Sriwulan in 2020 is 10,430 which consists of 5,202 males and 5,228 females. The householders reported 2,811 males and 657 females. The educational background and the livelihood of Sriwulan village population were described in Figures 2 and 3.

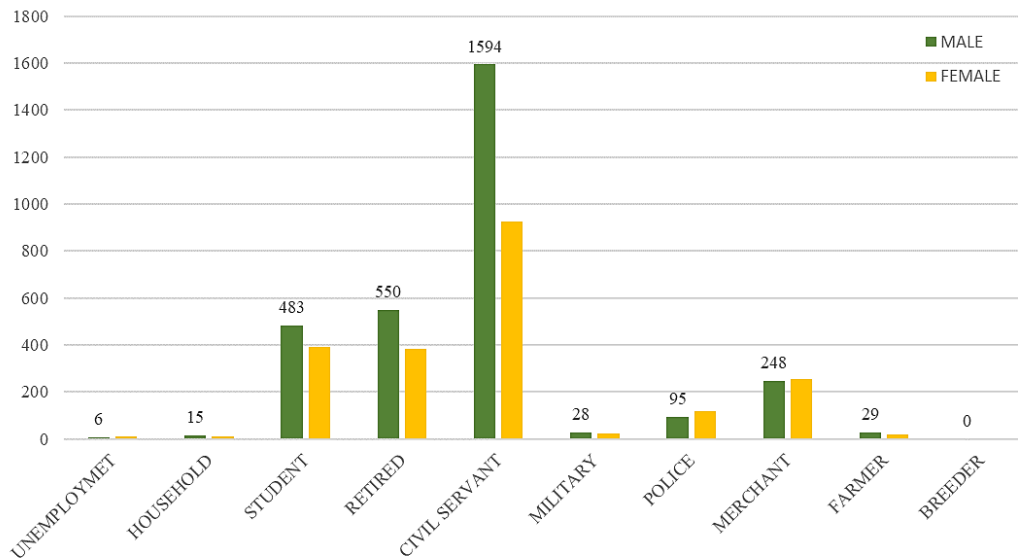


Figure 2. Educational background of Sriwulan village population

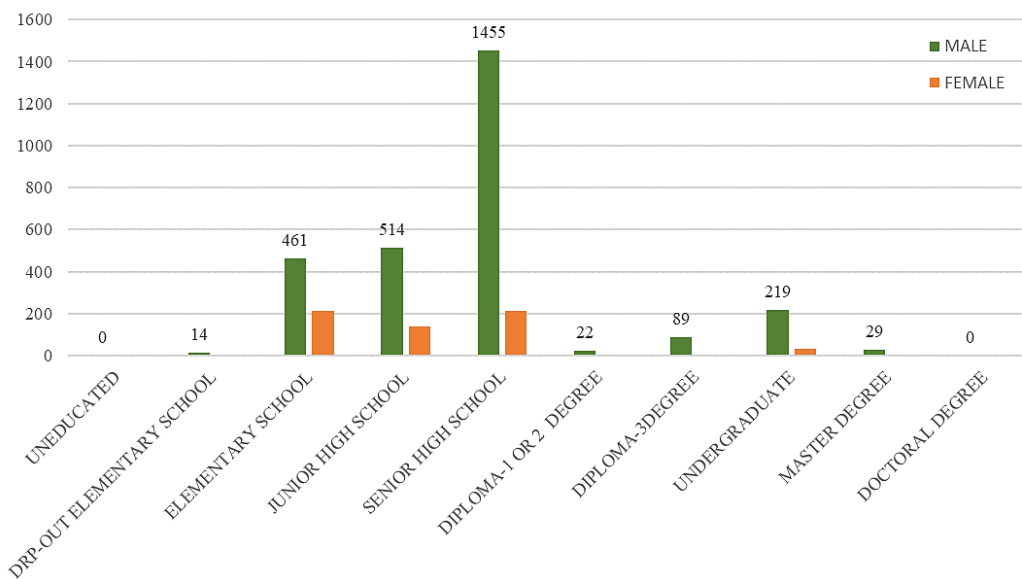


Figure 3. Livelihood of Sriwulan village inhabitants

## 2.2. Methods

The research was conducted by descriptive-qualitative method to produce a gender eco-friendly Sriwulan village's master plan. It was important to portray the existing situation of Sriwulan village which is submerged continuously by tidal flooding and to study the previous data of tidal flooding in Sayung District and Sriwulan village by using the method. There were questionnaires for the survey to 25 respondents (women and men) and an in-depth interview with 3 (three) women's community representatives who live in Sriwulan village, Sayung District, Demak Regency.

The master plan was created in several stages as described in Figure 2 which could be explained as follows.

1. **Preparation stage.** In this stage, a survey and observation were conducted to gain information, including need assessment, field observation, and Focus Group Discussion with the people and village authority of Sriwulan village.
2. **Data collecting.** The purpose of data collecting is to provide accurate information to be analyzed. Data collection was conducted by questionnaires and in-depth interviews with the respondents. The data collection has been conducted by qualitative purposive and quantitative random sampling of the respondents. There were 2 main issues delivered to the respondents in questionnaires and also in-depth interviews: (1) women's knowledge and capacity of tidal flooding disaster risk reduction, and (2) women's groups participatory in tidal flooding disaster risk reduction.

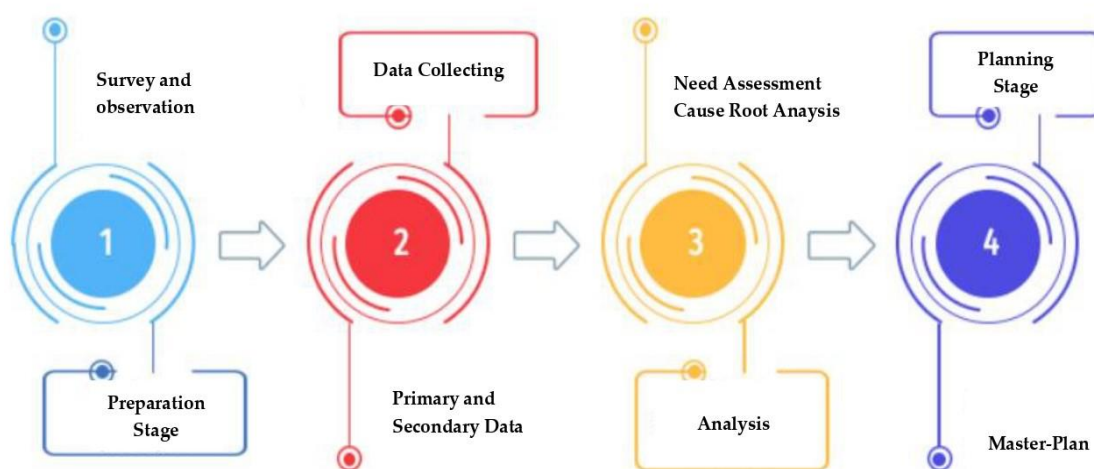
3. **Analysis.** A comprehensive analysis has been conducted based on survey and observation results and data from questionnaires and in-depth interviews. The analysis results will become a basis to create the master plan.

4. **Planning stage.** Zoning will be an initial step in the planning stage prior to planning itself. A map of a satellite image of Google Earth has been used as the basis of the master plan. The determination of zoning implemented based on analysis results and data. There was also the placement of an evacuation route and tidal flooding detector on the master plan. This stage is the final stage which produced a gender eco-friendly master plan for Sriwulan village for a sustainable built environment.

## 3. Result and Discussion

### 3.1. Results of Observation of the Impact of Tidal Flooding Disaster in Sriwulan Village

The sinking of Sriwulan village is a long process of coastal erosion caused by climate change which had begun in 1925 [17,37]. It was reported by Ruswanto [37] that during the period of 1925-1964, the coastline of Demak Regency was reduced to 200 m, and in the next 20 years later, in 1984, the coastline was also reduced to 200-300 m, about 12,5 m per year. The same report stated that in November 1955, the coastline of Demak Regency was reduced to 55 m. Another report [16] found that the coastline of Sayung village changed from 2003 to 2013 from 4.49 km to become 10.38 km.



**Figure 3.** The Stages to Create the Master Plan





(photograph ©Susilorini, et. al., 2021)

**Figure 4.** Existing situation in Sriwulan village, Sayung District, Demak Regency, November 5, 2021



(photograph ©Susilorini, et. al., 2021)

**Figure 5.** “Mr. Boat Man” of Sriwulan village, Sayung District, Demak Regency, November 5, 2021

During the last two decades, the depth of tidal flooding in Sriwulan village has become higher and higher. Tidal flooding's intensity and depth were reported in several years during 2008-2022 [4] as described in Table 1. In 2008, the depth of tidal flooding was reported as 0.25 m [4,7,12] while in 2017 authors reported in that the depth of tidal flooding achieved 0.5 m [7]. In 2020, [12] reported that the depth of tidal flooding in Sriwulan village has achieved 1 m while the present investigation of authors, in November 2021, it is found that the tidal flooding disaster in Sriwulan has become worse than the maximum tidal flooding depth has achieved 1.5 m as shown by Figure 4.

**Table 1.** Tidal flooding's intensity and depth in Sriwulan village (2008-2022)

	2008	2017	2020	2021	2022
Intensity (per year)	2	2 to 3	5	> 6	> 6
Depth (max)	0.25	0.5	1	1.25	1.5

The field survey of this research has observed that the disaster of tidal flooding in Sriwulan village is the worst in the last 5 years that the depth of tidal flooding has been increasing in exponential trend. Obviously, Figure 5 explains the sinking Sriwulan village (houses, public facilities, road, etc.) submerged by tidal flooding more than

6 (six) times a week with depths of about 0.5-1.5 m. Mr. Nasikin 'Yatin', "Mr. Boat Man" (Figure 5), lives in RT. 6/RW. 2, Sayung village, with his family in their house with a floating boat inside the building. They built a simple wooden bridge to connect their tidal flooding submerged house with the road. It was also found that several Small and Medium Enterprises existed in Sriwulan Village which is located in business zones in the village that suffered from tidal flooding.

**3.2. Results of Questionnaires and In-Depth Interview**

The questionnaires were delivered by a Likert scale of five-point agreement (strongly agree, agree, strongly disagree, disagree, and undecided) as described in Table 2 while the control score is shown in Table 3.

Figure 6 described the response of the parameter of women's knowledge and capacity of tidal flooding disaster risk reduction. It has found that women's knowledge and capacity of tidal flooding disaster risk reduction 75.36% were good and 26.64% were fair. The second parameter response is women's groups participatory in tidal flooding disaster risk reduction shown in Figure 7. In this parameter, the response consists of good, fair, and bad. It was found that 28.07% of responses were good, 62.69% were fair, and 9.24% were bad.

**Table 2.** Parameter and score of questionnaires

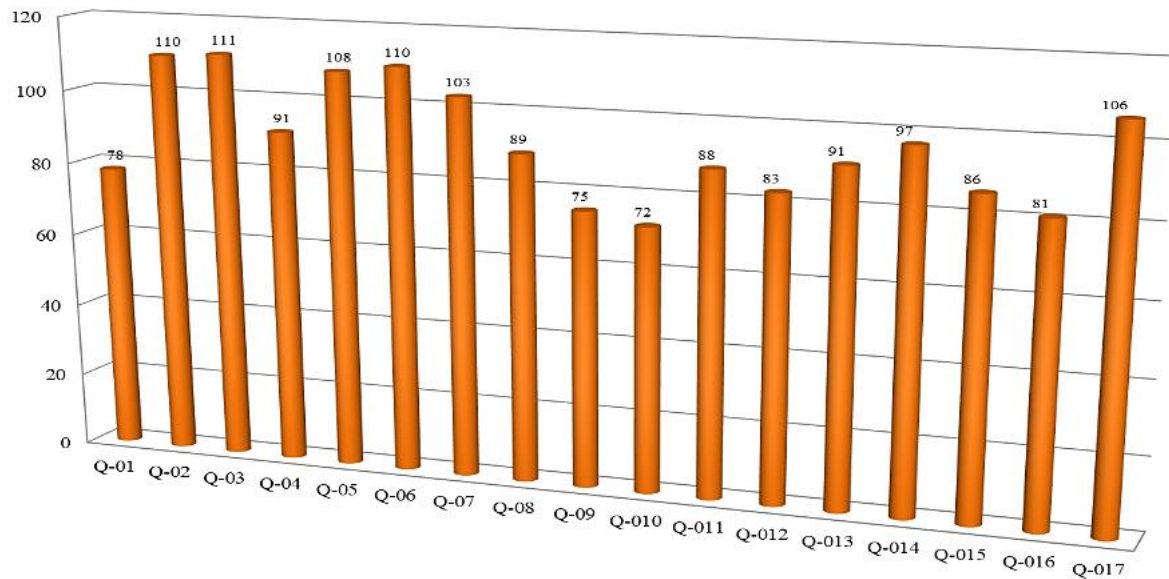
PARAMETER	NUMBER OF QUESTION	QUESTION TYPE	NUMBER OF QUESTION WITH TYPE OF A OR B	SCORE*				
				SA	A	SD	D	U
1	17	A	16	5	4	3	2	1
		B	1	2	3	4	5	1
2	17	A	14	5	4	3	2	1
		B	3	2	3	4	5	1

\*Note: SA=Strongly-Agree; A=Agree; SD=Strongly-Disagree; D=Disagree; U=Undecided

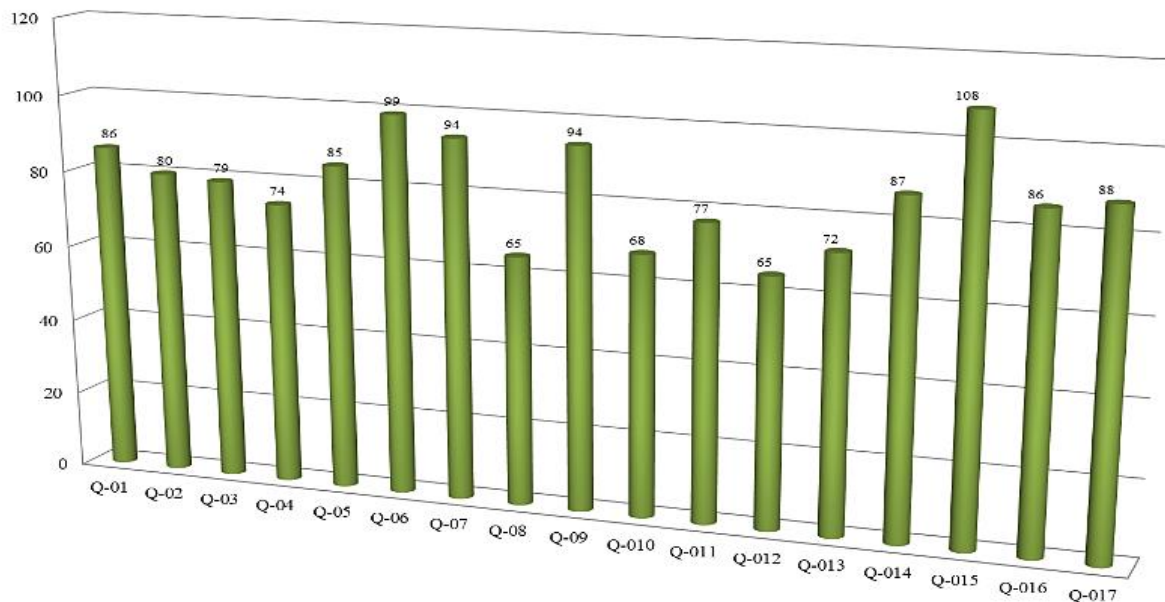
**Table 3.** Control for scoring

CONTROL	SCORE
Highest Score / Good	91-125
Medium Score / Fair	65-90
Lowest Score / Bad	25-64





**Figure 6.** Response of first parameter of women's knowledge and capacity of tidal flooding disaster risk reduction questionnaires



**Figure 7.** Response of parameter of women's groups participatory in tidal flooding disaster risk reduction

The fact came from the results of in-depth interviews with the representatives of women's community that women are the most vulnerable group during the disaster event, the tidal flooding in Sriwulan village. They said that they have very limited access to clean water, food, and medicine during the event of tidal flooding. It is a fact that the women were the ones who only can stay at home which has conditions submerged by the dirty water of tidal flooding which even come into the house. However, women still have the potential in promoting disaster risk reduction because women have a higher depth of sensitivity and concern for family members, and the surrounding

community [38]. In the case of Sriwulan village, women have the ability to adapt and to take the initiative during disaster events, including taking the place of their jobless husbands as breadwinners during the Covid-19 pandemic. It was proven that women are stronger in protecting their children and family when the disaster happened, included tidal flooding in Sriwulan village. An important thing should be noted that women had difficulty getting access to information, training, and workshop about adaptation to climate change. There are no opportunities for women to get involved in village development planning which is very important to change the faith of their sinking village

Sriwulan. Hence, the result of the questionnaire analysis (Figures 6 and 7) has proven that the women participatory in tidal flooding disaster risk reduction was fair. Women still have limited access to contribute in decision making of many policies in the issues of tidal flooding disaster risk reduction as well as the future of their village.

### 3.3. Discussion

The survey, observation, and in-depth interview had given comprehensive data to be analyzed. The rapid increase of tidal flooding inundation and level in Sriwulan village as shown by Figures 2 and 3 may not be getting so severe if only there is a coastal barrier that prevents the tidal flooding from coming into the land. Since there is no coastal barrier infrastructure for prevention, then mangrove cultivation can become the best option even though it takes years to grow the mangrove. Figure 1 has emphasized that the government of Semarang City has taken action in rehabilitating the mangrove plantation in a coastal area, including Trimulyo village, in Genuk District, since 2004 until nowadays [39], but the Demak Regency government didn't take the same action. The mangrove cultivation in Trimulyo village has succeeded to grow in about 30 ha along the beach in that village [40]. An observation of the coastline of Sriwulan village in about seven years (2015-2022) also conducted in this research by satellite image map by Google Earth described in Figure 8. The areas with red borders in 2015 have been exposed lightly to abrasion, but in 2017, some parts of the area have already sunk and finally, in 2022 wider areas have been exposed to abrasion and get to sink.

Unfortunately, as mentioned by most respondents in an in-depth interview, the people in Sriwulan village don't conform to the prevention of their village from tidal flooding with mangrove cultivation. Therefore, it is necessary to grow mangrove forests with proper technique in front of the village's coastal area and place the tidal flood detector (it can be operated manually or digitally). In the master plan, there is a big area planned for mangrove forests. It was also obvious that an alert zone with a tidal flood detector is very important to exist in the master plan. The evacuation routes will be built properly with sufficient signs to guide people to reach the assembly point in the event of a disaster.

This research found that women have a limited role in tidal flooding disaster risk reduction and adaptation. There is insufficient information, training, and workshop about climate change, disaster risk reduction, and adaptation. It was also found that gender mainstreaming has not been implemented yet in tidal flooding disaster risk reduction in Sriwulan village. Due to COVID-19's impact on economics, it was unfortunate that many householders lost their job and were substituted by women (their wives). In

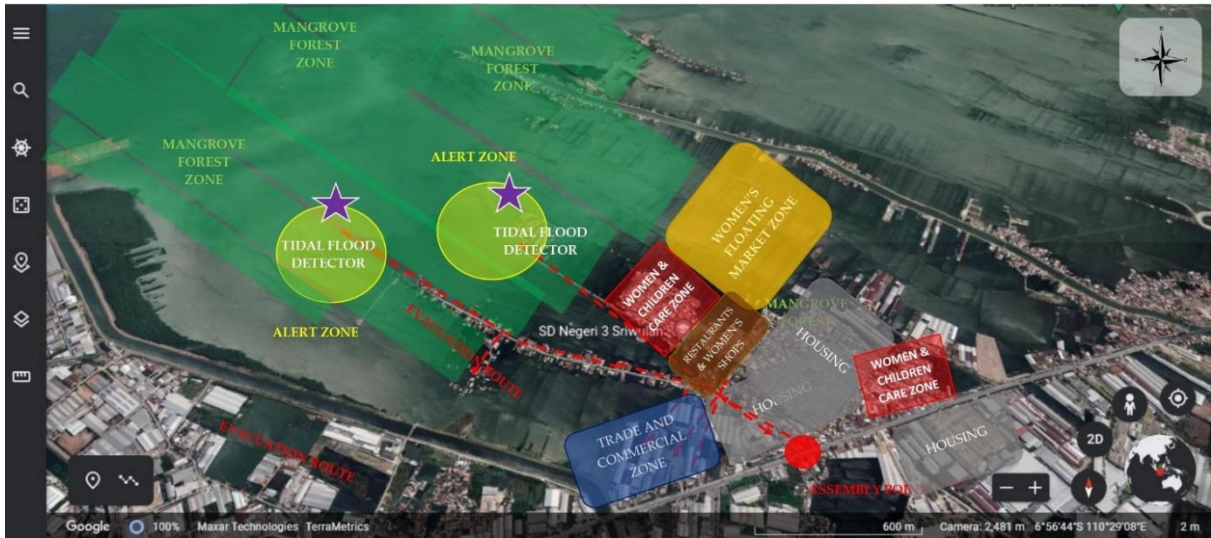
several programs, it was found that village authority doesn't take special attention to gender mainstreaming in policy or regulation as well as development. Hence, it is important to encourage women, to give them the opportunity and role as 'actors' in leading the community to cope with the climate change impact for a better future by increasing their capability and good knowledge. Hence, there should be a place for women and children to stay to become resilient and feel safe in Sriwulan village. In the master plan, this issue has been implemented as a 'women and children care zone'. In the future, women also take an important role in domestic and also village economic increases by selling miscellaneous products in floating markets nearby the mangrove forest. They can also manage restaurants and shops and develop their business capability.

From the questionnaires and in-depth interview analysis, the people in Sriwulan Village necessarily need their village future to be prolonged by the natural barrier of the mangrove forest to struggle with the tidal flooding disaster. They also wanted the government to take action to work together to plant Mangroves and change the face of the village from a sinking village to become a prospective eco-tourism village. The people want the economy of the village is going to be supported to be wealthier by trade and commercial activity which is placed in a safe zone. The women have the idea that their village has a women's floating market, restaurants, and shops, to support their eco-tourism village.

Hence, due to the need of the Sriwulan Village to change their village to be an eco-tourism village, a comprehensive analysis conducted on the existing map of Sriwulan Village which finally create the **"Gender Eco-Friendly Master Plan for Sustainable Built Environment of Sriwulan Village"** (Figure 8) by stages of planning described by Figure 2. Several zones were determined and plotted to the basis map which is a satellite image map of Google Earth. Several zones of the **"Gender Eco-Friendly Master Plan for Sustainable Built Environment of Sriwulan Village"** (Figure 7): (1) the mangrove zones; (2) alert zone with tidal flood detectors; (3) evacuation routes with assembly point; (4) women and children care zone; (5) women's floating market zone; (6) restaurant and women's shops zone; (7) trade and commercial zone; and (8) housing. After plotting the zones, the Master Plan was completed by adding the evacuation route and the placement of tidal flooding detectors made by the authors. Data and analysis of tidal flooding inundation, topographic and population secondary data from any sources and the comprehensive analysis of purposive sampling data of respondents by questionnaires and in-depth interview were contributed significantly in Master Plan creation. The master plan is expected to give a better future to Sriwulan village, especially to adapt to tidal flooding and put the women as an actor in the sustainable built environment of Sriwulan village's.



**Figure 8.** Satellite image map by Google Earth of the coastal area of Sriwulan village from 2015-2022 taken by authors



**Figure 9.** The Gender Eco-Friendly Master Plan for Sustainable Built Environment of Sriwulan Village that was created by authors that using Google Earth Map as a basic map

It should be noted that there is critical thinking to create those zones mentioned above based on data and analysis. The mangrove zones are needed to begin now but it will take more than 10 (ten) years to get a ‘real’ mangrove forest as a natural barrier that is going to support the eco-tourism village of Sriwulan. The alert zone with a tidal flood detector is a major component of the “Early Warning System” (EWS) of tidal flooding disaster risk reduction. There are 2 (two) tidal flood detectors placed on the waterfront which will first face the high tide and tidal flooding. In other disaster events, for an instant in many events of the tsunami disaster, EWS has taken an important role in saving lives and also giving people enough time to evacuate [41–45]. Hence, we place also 2 (two) evacuation routes in the village to reach assembly points. Supporting the disaster risk reduction in the stage of emergency of the disaster event, it should be placed the women and children’s care zone to answer the need for safety, a comfortable place to live, to take care of a mother and her children, and also women who need shelter in the event of a disaster. At the time of the disaster event, several economic zones should be built to support a gender-responsive Master-Plan as the solution to change the face of Sriwulan village from the Sinking Village to become a gender-responsive Eco-tourism Village. Since many

women previously sold many products of seafood or other marine food products and also vegetables, they will have a safe and comfortable floating market that also serves culinary products in the restaurants as well as handy craft and other miscellaneous products in the shop in the women’s floating market zone and also restaurant and women’s shops zone. There is also a public market, shops, and mini market, in the commercial zone. The zones of housing which were maintained were located nearby the main road. It seems that the housing nearby the sea (waterfront area) will not survive in the near future. Hence it is wise to plan the housing far away from the entry of tidal flooding.

## 4. Conclusion

The research found that women have a limited role in tidal flooding disaster risk reduction and adaptation in Sriwulan village. There is insufficient information, training, and workshop about climate change, disaster risk reduction, and adaptation to tidal flooding. Women should be given opportunity as an actor in leading the community to cope with the climate change impact for a better future by increasing their capability and good knowledge. In general,

in the future, village life will be prolonged by the “Gender Eco-Friendly Master Plan for Sustainable Built Environment of Sriwulan Village” created by placing several zones such as: (1) the mangrove zones; (2) alert zone with tidal flood detectors; (3) evacuation routes with assembly point; (4) women and children care zone; (5) women’s floating market zone; (6) restaurant and women’s shop’s zone; (7) trade and commercial zone; and (8) housing. The master plan is expected to give a better future to Sriwulan village, especially to adapt to tidal flooding and put the women as an actor in Sriwulan village’s sustainable built environment.

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