



**Flood
Resilience
Alliance**

Summary Report

CLIMATE RISK AND IMPACT ASSESSMENT

Kupang Watershed

Mercy Corps Indonesia



IPB University
Bogor Indonesia



CoREM
Center for Coastal Rehabilitation
and Disaster Mitigation Studies

In partnership
with:



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1.1 | Background

Pekalongan City and Regency have been continuously affected by flood and tidal flood. From 2002-2020, 66 flood cases have been recorded in the area (BNPB 2020). The flood originate from a combination of intensive rainfall, changes in land use and river body, as well as the sea tides (Pasaribu et al. 2013). Historically, Pekalongan coastal area has been experiencing sea level rise of 5 mm/year (COREM-UNDIP 2020), which is higher than that of Java Sea, which is generally at 3.9 mm/year (Kismawardhani et al. 2018). The area also faces constant land subsidence, which was identified to range between 10-17 cm for the period of 2012-2018 (Tempo, 2019).

The recurring floods have caused not only physical (infrastructure) damages, loss of land due to permanent inundation, but also decreased community's income and increased their expense for flood anticipation. This condition has posed additional burdens to the directly-affected community as well as local government's fiscal situation.

The high level of dynamics in physical changes in the coastal area as well as area development have increased the complexity of flood events. Climate change impacts will further increase such a complexity. To formulate the appropriate controlling measures, proper understanding on flood causal factors, interaction between factors, and the area's ability in responding to flood are critical.

Reflecting on this condition, the development of an impact model capable of explaining the cross-factors interaction in a complex system is highly needed. The development of a Study on Climate Risks and Impacts Assesment in Pekalongan City and Regency is a preliminary process to build such an understanding.



*The study will **analyze the threat of flood and tidal flood** facing the location, **review the location's vulnerability** (from physical, environmental ecological, social-economic, and institutional aspects), and **analyze the risks** developed from such threat and vulnerable condition. The results will serve as **THE BASIS FOR RECOMMENDATION** to enrich policies of Pekalongan City and Regency.*

Landscape perspective and transboundary governance are two key terms that shall be adhered to by any stakeholder involved in the development of this study. The understanding that Pekalongan City and Regency are located in one single landscape unit is the fundamental reason of using landscape perspective in the analysis process. The sub-systems interaction within the unity of the landscape is undoubtedly dynamic, where they also influence each other. Any changes or interventions to be carried out in one location might bring about impacts to another location, which might be located within a different administrative area, thus making transboundary governance significant in any flood mitigation efforts.

1.2 | Geographic Scope

The study locus is the Kupang watershed area located within City and Regency of Pekalongan, and the coastal area of both municipalities.

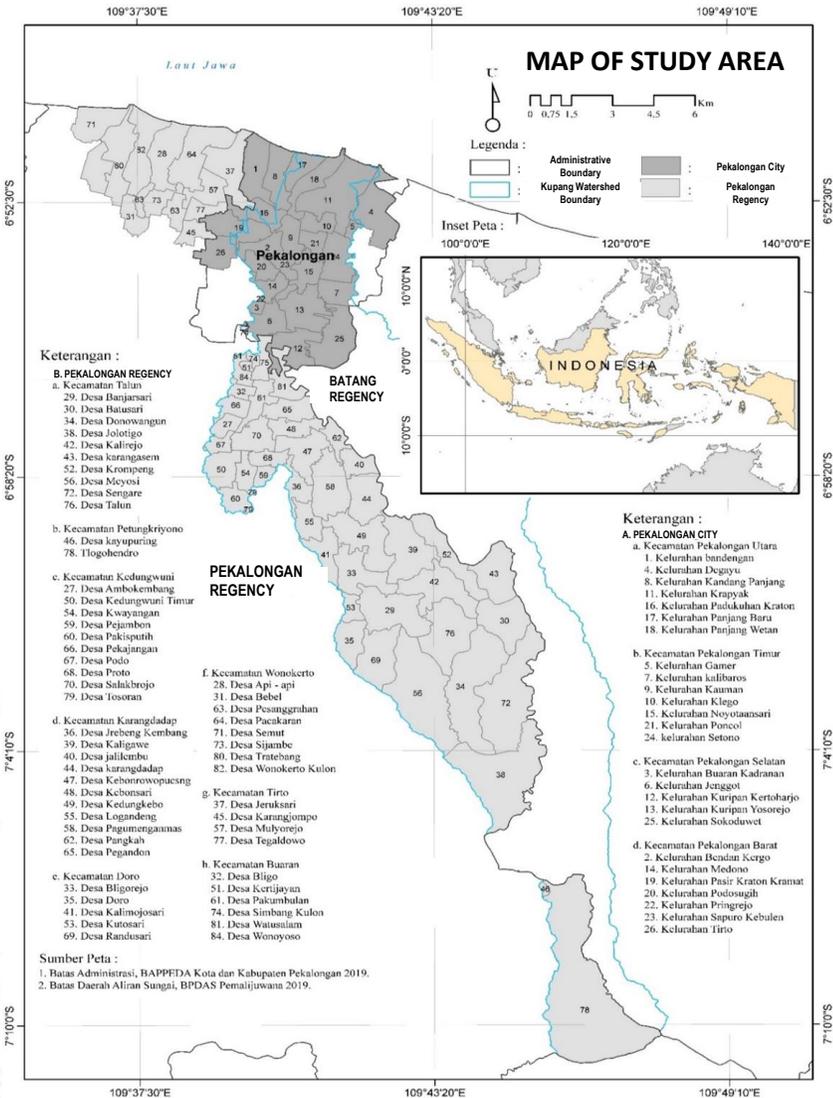
To represent the areas affected by flood and tidal floods, the focus of the study's geographic coverage was the upstream areas all the way to downstream areas of Kupang Watershed that are located within the administrative area of Pekalongan City and Regency, and the coastal area of Pekalongan City and Regency. There were a total of 84 villages/*kelurahans* covered in the study.

Although Kupang Watershed also passes across Batang Regency, for the purpose of this study, the villages in Batang District which are part of the Kupang Watershed were not included into the geographic scope.

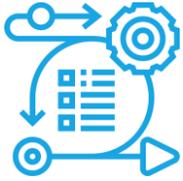
1.3 | Study Limitation

The study process contains several limitations that need to be recognized, namely:

- ✓ The villages/*kelurahans* within Kupang Watershed that are located in Batang Regency were not included into the study location, although they are still included as part of the model in climate and hazard modeling process to ensure that interactions between factors are still put into consideration.
- ✓ The rate of land subsidence was assumed to be constant every year, which was based upon data from the analysis results on land subsidence conducted during the study (data of 2019).
- ✓ Land use in the hazard analysis process was assumed to be constant throughout the projection period. However, land use change was accommodated in vulnerability and risk analysis process. The modeling of land use change tends to apply a relatively-controlled development scenario.
- ✓ Hazard analysis will only model inundation and hazard for decadal prediction and RCP 4.5 scenario (without RCP 8.5); RCP 4.5 will utilize the percentile 95 to represent the worst condition that might take place (although in mid-term and long-term, this scenario is considered moderate).
- ✓ Hazard and risk analysis processes utilize landscape analysis unit (grid scale), while vulnerability analysis utilizes village/*kelurahan* analysis unit.
- ✓ Due to limited data and types of indicators, not all indicators are projected dynamically in the process of vulnerability index projection.



Map of Study Area



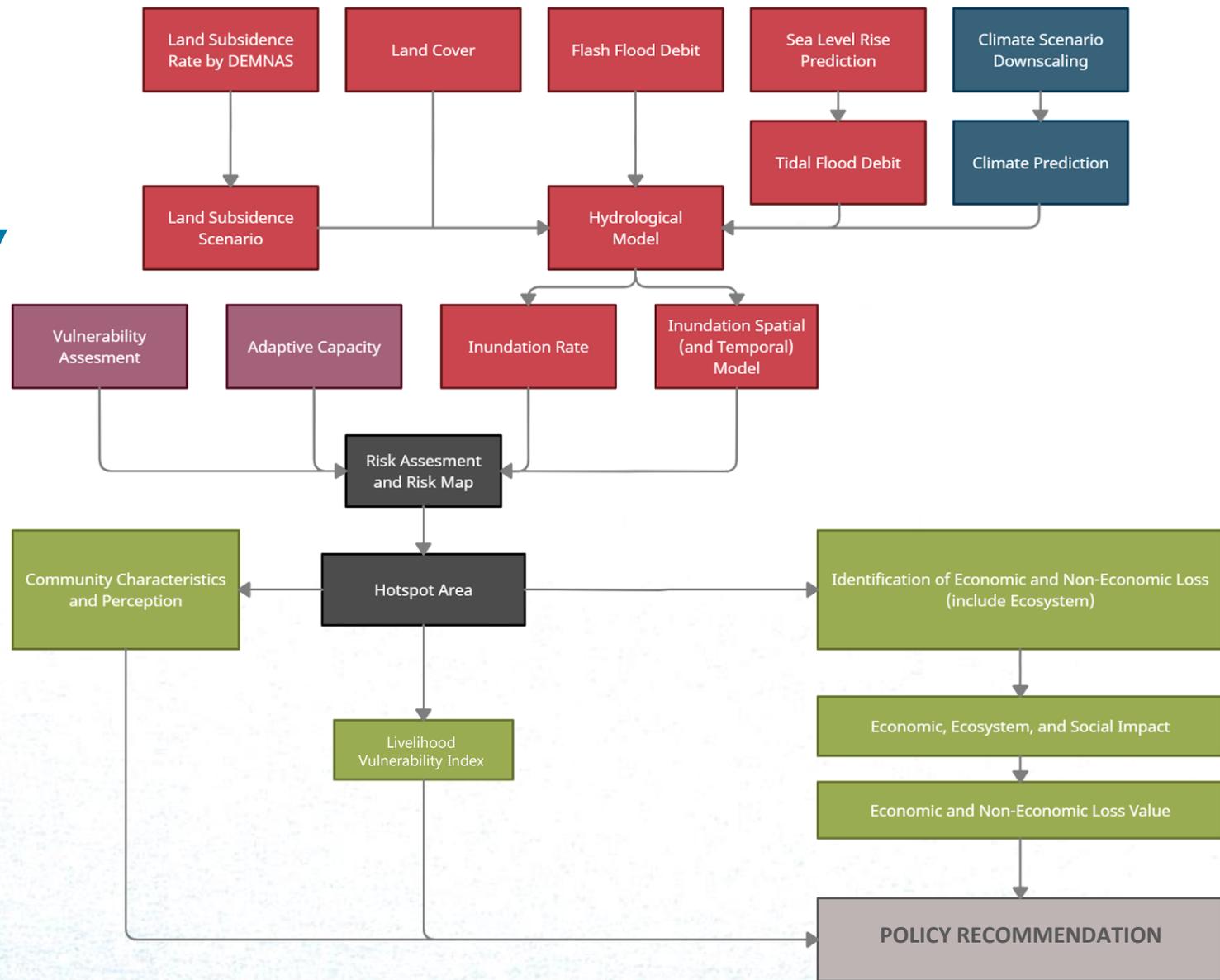
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METHODOLOGY

2.1 | General Framework

This general framework of Climate and Impact Risk Study refers to **the Six Steps Approach (GIZ, 2018)**, which is mainly aimed at understanding the climate-related impacts and risks in a study system and identify the appropriate controlling steps.

The study consists of the processes of hazard analysis, vulnerability analysis, risk analysis, as well as economic and non-economic impact analysis of flood and tidal flood events. The four analysis processes highlighted the importance of interconnection and mutually complementary/verification process between various analysis components as shown in the flow chart.



General Framework

2.2 | Hazard Analysis Method

The steps of hazard analysis method within this study comprised climate modeling (climate change projection) in the study location, sea level rise projection, simulation of condition and projection of flood spatial model, and also hazard analysis. The analysis process was conducted for baseline condition and 5-yearly projection until 2035 (for decadal) and 25-yearly projection until 2095 (for long-term projection).

A. Climate Modelling

Climate modeling is commonly carried out to **identify the influence of climate factor toward changes of intensity and frequency of flood and tidal flood** in the study location, as well as impacts of the interaction between climate factor, land physical condition, and sea parameter to the flood event.

Considering the rapid physical changes taking place in the studied coastal area and the urgency for short-term recommendations for policy formulation purpose, the **climate modeling process** in this study will also involve **near-term projection (decadal prediction) in addition to long-term one.**

Decadal prediction utilized hindcast and forecast database published by Global Climate Model (GCM) from the Climate Model Intercomparison Project Version 5 (CMIP5) which was specially designed for projection of short-term climate change that was based on prediction of decadal and interdecadal climate variability. The global data was afterwards downscaled to capture the local characteristics of the studied location and reduce biases in the global model output. The downscaling calculation was also used to develop the National Mid-Term Development Plan (RPJMN) of 2020-2024. The decadal prediction for this study was developed **for 5-yearly period covering 2020-2035, and the components that were analysed were probability of monthly rainfall characteristics and wet extreme index.**

Downscaling to the GCM was also used in the **long-term projection** process to increase the resolution of spatial and temporal data. The projection also utilized the daily resolution outputs from the Regional Climate Model (RCM) to calculate more detailed extreme index. Basically, climate projection was based upon the possibility of radiative forcing flow caused by the increase of green house gas emission. While the decadal prediction emphasizes on the influence of natural factors to low frequency climate variability, long-term climate projection stresses on the role of anthropogenic influence to future climate change, which is marked with the increase of GHG emission in the atmosphere.

The long-term climate projection was illustrated into 2 scenarios, namely RCP 4.5 to represent moderate scenario, and RCP 8.5 to represent extreme scenario. The **components that were analysed** in the long-term projection were **rainfall** and **extreme index.**

	DECADAL PREDICTION	LONG TERM PROJECTION
USER	Policy and decision makers	Researcher
SCENARIO	Near term up to 2035	Long-term up to 2095 with RCP 4.5 and RCP 8.5
DATABASE	Statistical downscaling hindcast and and GCM forecast	Downscaling GCM and RCM
ANALYSIS COMPONENT	<ul style="list-style-type: none"> Probability of monthly rainfall anomaly Wet extreme index 	<ul style="list-style-type: none"> Rainfall Extreme index (wet and dry)

Utilization of IPCC AR-5 Climate Model Processed for Study Location (Source: Moss et al. (2010))

B. Projection of Sea Level Rise

The projection of sea level increase until 2040 was carried out by utilizing the database on annual sea level from the outputs of RCP 4.5 model (for Pekalongan and its surrounding area). The average spatial value of this model output was subsequently corrected with altimetric historical data from Copernicus.

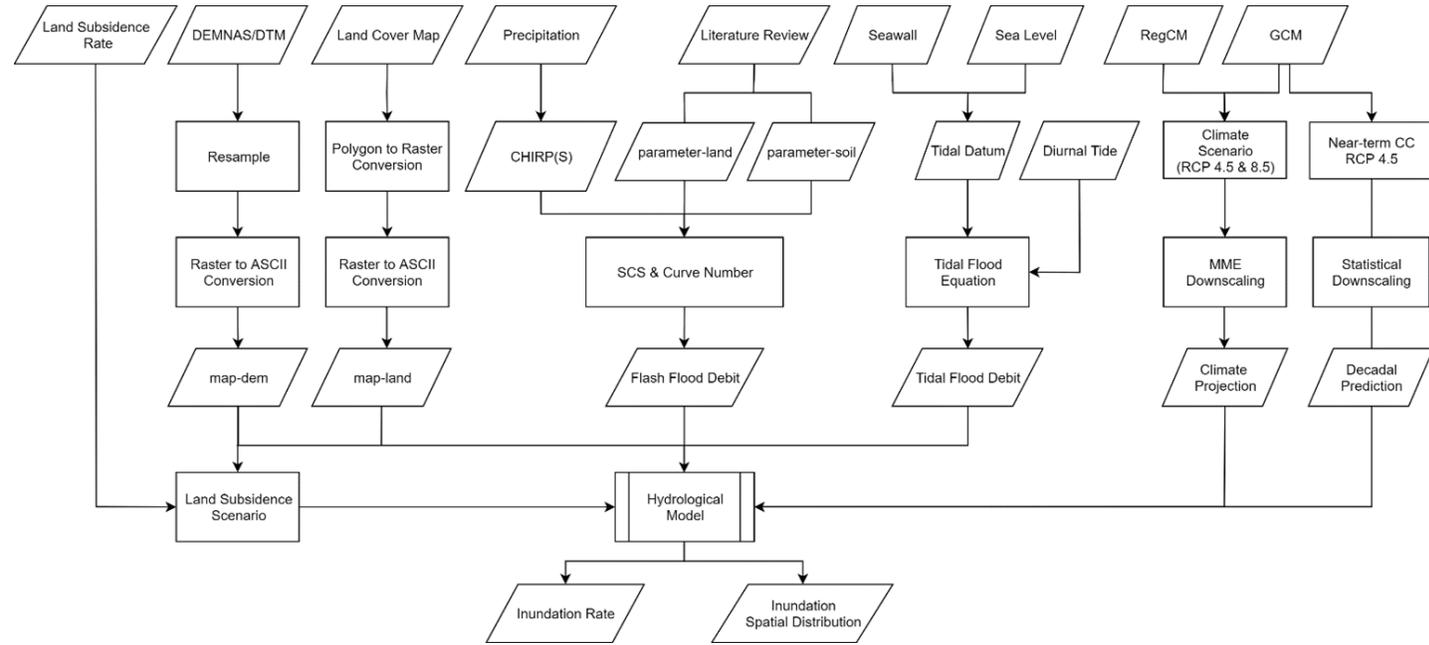
C. Flood Model Development

The flood model was utilized by using the Agent-Based Modelling (ABM) process with spatial resolution of 30x30 m. ABM is a computational model that positions an agent as an object that can interact and respond to the land's physical condition (Condro and Widagdo, 2017).

In this study, rain water and sea water (in debit form) were set up as an agent, and the responses of both to the environmental condition were defined as the inundation level which has spatio-temporal dimension.

In the ABM simulation process, the rain water/sea water debit will move in every time unit. The movement is influenced by its interaction with the climate factor and land's physical properties, which in turn will generate the value of inundation level both temporally and spatially.

The physical land anomaly is represented by data from Digital Terrain Model (DTM) which have been corrected with field measurement (with geodetic GPS), data on land subsidence, as well as data on land coverage and type of soil to calculate the abstraction of rain water and sea water within the study location.



Framework of Flood Model Development for the Study Location (Author Team 2020))

D. Hazard Analysis

Flood hazard index for each projection period was determined based on the inundation level and land level from the ABM simulation result on every grid.

For locations with baseline land elevation under sea level, the inundation level value was made from sea level value minus the relative land height against the datum.

CATEGORY	INUNDATION LEVEL	INDEX VALUE
Not affected (NA)	0 cm	0
Very Low (VL)	0.01-4.2 cm	0.2
Low (L)	4.2-31.7 cm	0.4
Moderate (M)	31.7-77.83 cm	0.6
High (H)	77.83-192.74 cm	0.8
Very High (VH)	>192.74 cm	1

Categories of Flood Hazard in the Study Location (Author Team, 2020)

2.3 | Vulnerability Analysis Method

The Intergovernmental Panel on Climate Change defined vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity”. Thus, vulnerability can be measured with three dimensions, namely level of exposure, sensitivity, and adaptive capacity.

Vulnerability Analysis Dimensions:

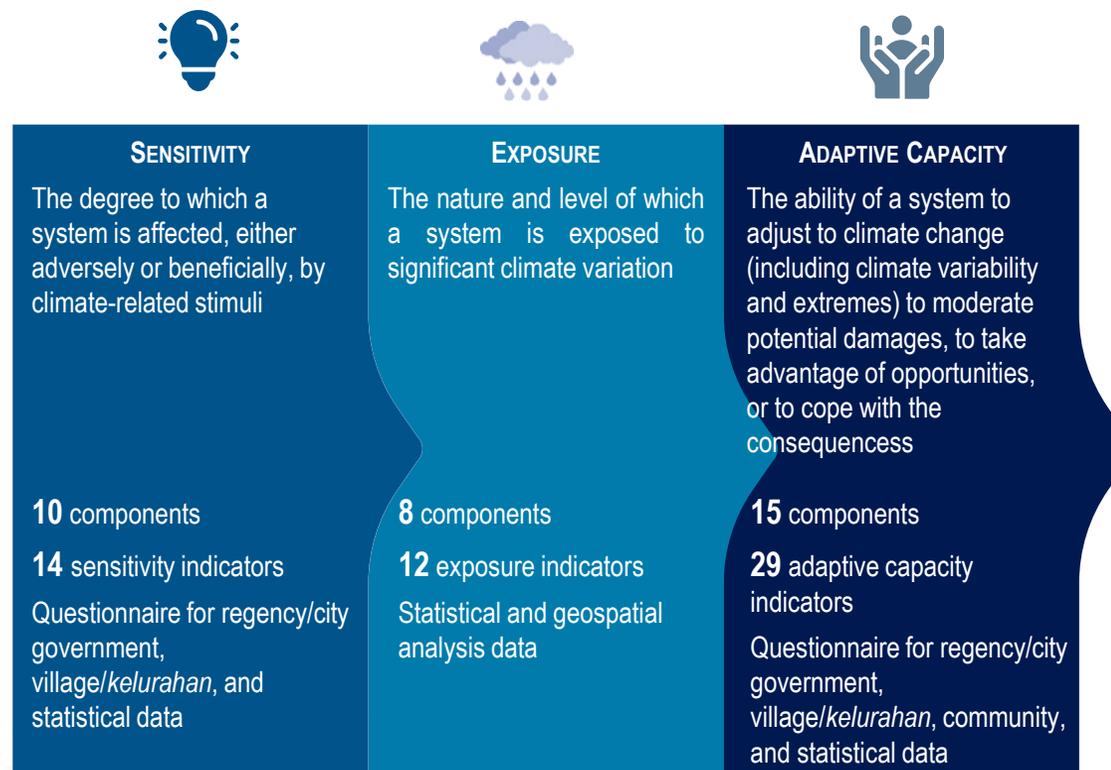
1. Sensitivity
2. Exposure
3. Adaptive Capacity

The steps of vulnerability analysis in this study comprised of sensitivity analysis, exposure analysis, adaptive capacity analysis, and vulnerability analysis. **The analysis process is conducted for baseline condition and the 5-yearly projection (until 2035).**

The process of vulnerability analysis involved a series of indicators that numerous literature studies and FGDs with expert team considered as being able to represent the condition of sensitivity, exposure, and adaptive capacity in the study location. In the analysis process for each vulnerability dimension, this indicator was classified into several components and were respectively given weights.

The database of indicators was obtained from primary and secondary data collection, both spatial and non-spatial ones, which comprised geospatial data analysis (for spatial-based data), questionnaire (community, regency/city governments, and village/*kelurahan*), and statistic data collection at village/*kelurahan* level.

In the vulnerability analysis process, an analysis on land use change and land subsidence was also conducted to further increase the accuracy of the analysis.



Building Blocks of Vulnerability in Climate Risks and Impacts Study (Author Team, 2020)



A. Sensitivity Analysis

The Sensitivity Index (S) is composed of 10 components that consists of 15 indicators that are considered as capable of representing the sensitivity dimension in the study location; each of the components and indicators are then given weight. The Sensitivity Index value was obtained from addition of values of all components being used in accordance with the weight given to each of those components. The index was afterwards divided into 5 classes, starting from very low to very high.

$$IS_i = \sum_{j=1}^n W_j * I_{Aij}$$

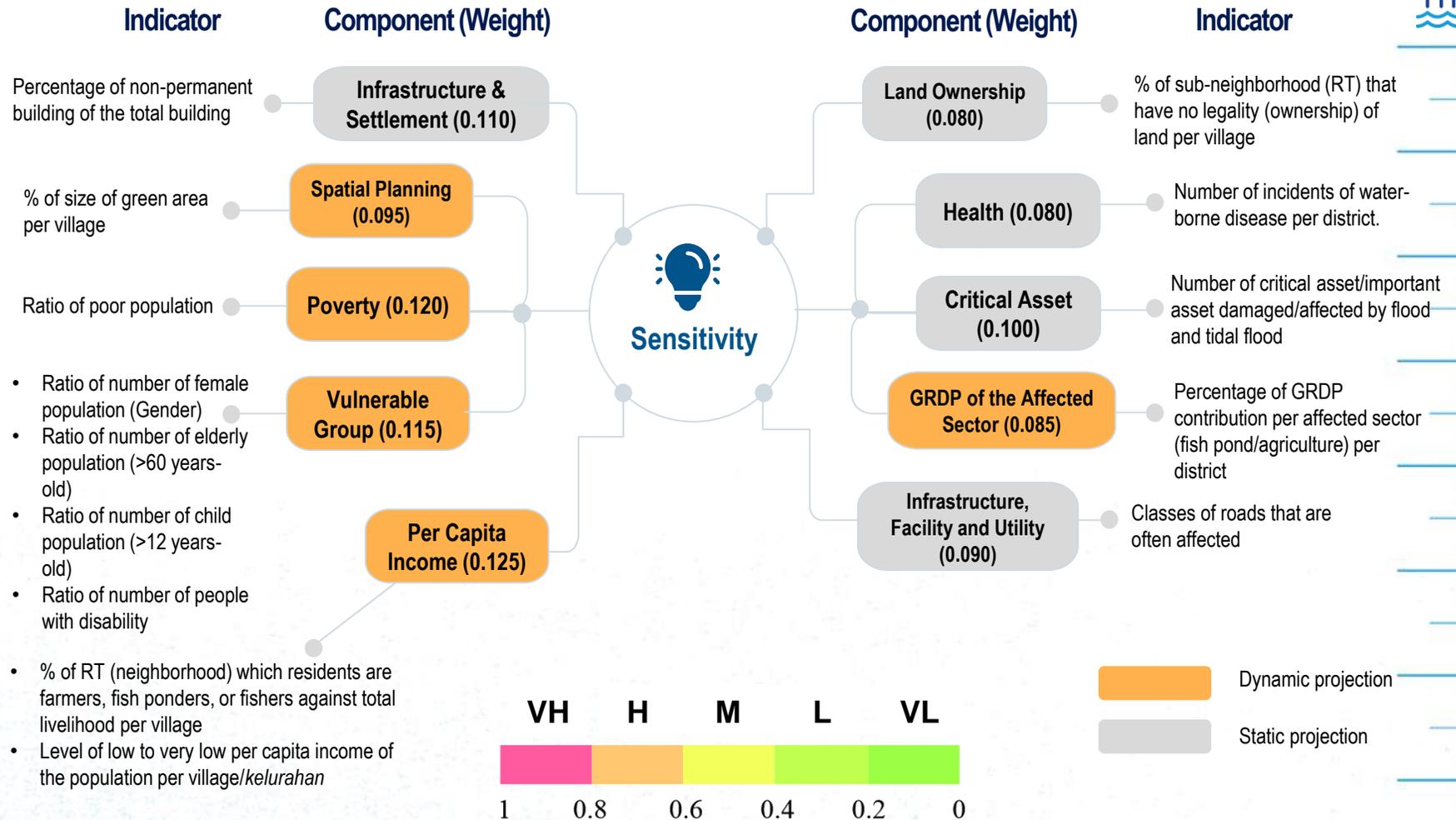
Description:

IS = Sensitivity Index

i = represents village/ *kelurahan* number- i ,

j = indicator number- j

W_j = weight for every sensitivity indicator



Component, Indicator, Weight and Class of Sensitivity Dimension (Author Team, 2020)

B. Exposure Analysis

Exposure Index (E) is composed of 8 components that consist of 12 indicators that are considered as capable of representing the exposure dimension in the study location; each component and indicator is then given weight. The exposure index value was obtained from the addition of value of all components being used in accordance with the weight given to each of those components. The index was afterwards divided into 5 classes, starting from very low to very high.

$$IK_i = \sum_{j=1}^n W_j * I_{Aij}$$

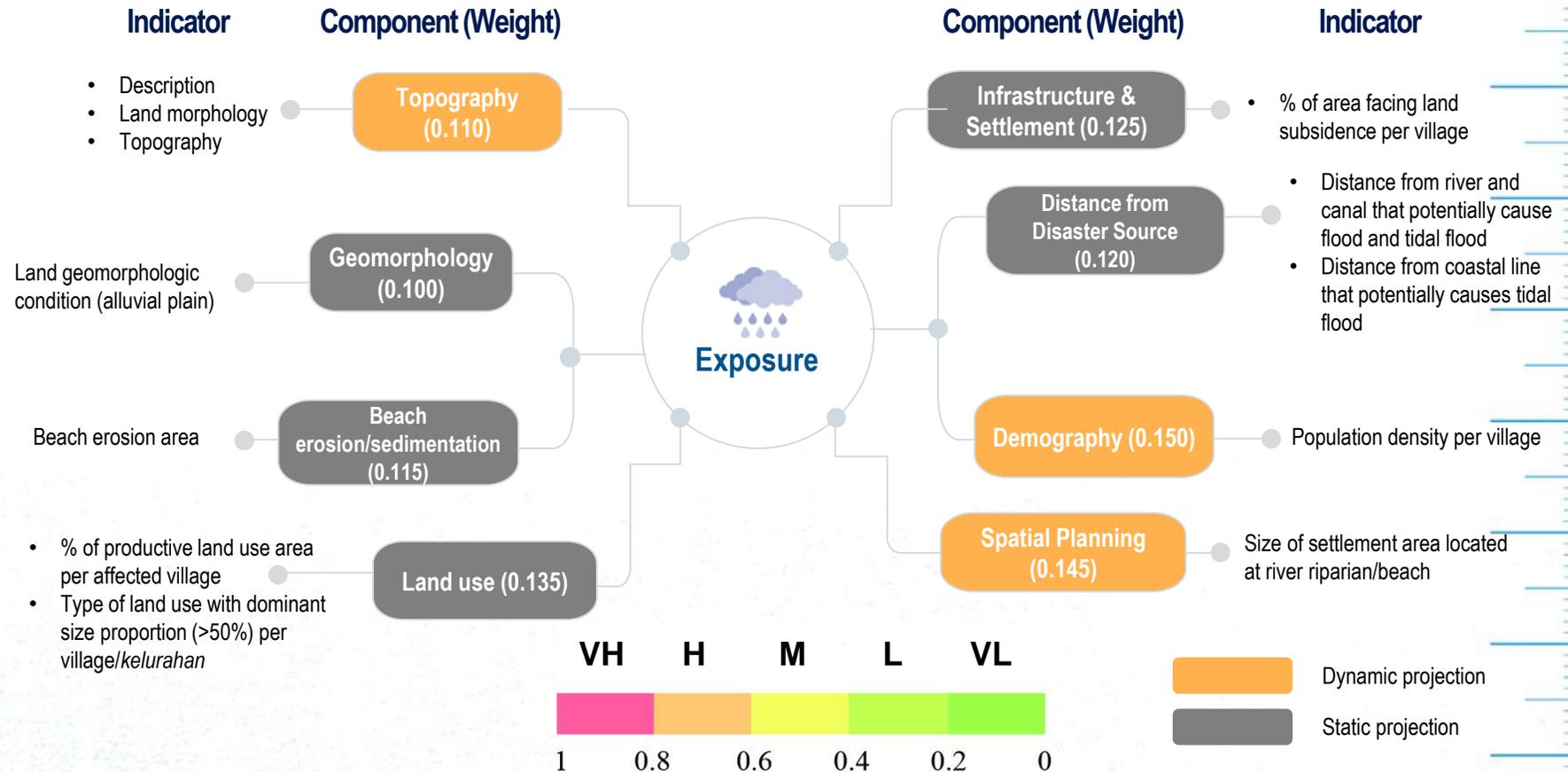
Description:

K = Exposure Index

i = represents village/*kelurahan* number- i ,

j = indicator number- j

W_j = weight for every exposure indicator



Component, Indicator, Weight and Class of Exposure Dimension Index (Author Team, 2020)

C. Adaptive Capacity Analysis

The **Adaptive Capacity Index (AC)** is composed of 15 components and 29 indicators that are considered to be able representing the adaptive capacity dimension in the study location; each component and indicator is then given weight. The value of adaptive capacity index was obtained from the addition of values of all components that were used in accordance with the weight given to each of those components. The index was afterwards divided into 5 classes, starting from very low to very high.

$$IKA_i = \sum_{j=1}^n W_j * I_{Aij}$$

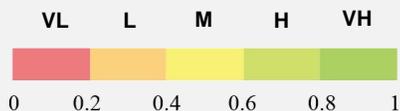
Description:

IKA = Adaptive Capacity Index

i = represents village/ *kelurahan* number- i ,

j = indicator number- j

W_j = weight for every adaptive capacity indicator



Static projection

Dynamic projection

NO	COMPONENT (WEIGHT)	INDICATOR
1	Regulation and Planning (0.095)	Regulatory support from spatial planning aspect
		Mitigation of flood and tidal flood in RPJM (Mid-Term Development Plan)
2	Disaster Financing (0.080)	Local financing support for flood mitigation
3	Disaster Early Warning (0.055)	Existence of early warning system for flood
		Existence of early warning system for tidal flood
4	Institutional arrangement in form of Disaster Service Center (0.065)	Existence of service center and information dissemination for flood and tidal flood
		Quality of government/agency's service in flood preparedness
5	Institutional arrangement in form of Community Group (0.060)	Existence of resilient (prepared) community group
		Background of establishment of disaster resilient community group, such as KSB (Disaster Preparedness Group), TSBK (<i>Kelurahan</i> Disaster Preparedness Group), SIBAT (Community-based Disaster Preparedness), etc.
6	Disaster Program (0.090)	Existence of disaster mitigation program
		Existence of conservation/rehabilitation program to overcome flood and tidal flood
7	Education, Counseling, and Knowledge for Community (0.050)	Ratio of higher education (SHS/VHS, IHS, and University)
		Counseling and assistance for mitigating flood and tidal flood
8	Disaster Mitigation (0.085)	<i>Kelurahan</i> /village scale disaster mitigation plan document
		Document and implementation of RAD PRB (Regional Action Plan for Disaster Risk Reduction) of City/Regency BPBD
9	Preparedness and Contingency (0.080)	Plan and steps of preparedness activity to mitigate flood
		Existence of SOP for flood emergency (contingency) situation
		Speed of emergency (contingency) implementation by government/agency during flood.
		Plan and steps of preparedness activity to mitigate tidal flood
		Existence of SOP for emergency (contingency) during tidal flood
10	Infrastructure for Flood and Tidal Flood Control (0.070)	Speed of emergency (contingency) implementation by government/agency during tidal flood.
		Existence of polder, retention pool, sea dike, etc.
11	Community's Perception toward flood and tidal flood (0.045)	Community's direct perception (response/acceptance) to flood and tidal flood mitigation programs
12	Local Wisdom (0.035)	Local wisdom associated with flood and tidal flood
13	Well-being (0.075)	Percentage of prosperous family
14	Infrastructure, Facility and Utility (0.070)	Availability of education supporting facilities and infrastructures
		Percentage of household regarding 'main fuel' used to cook per village (%)
		Limited clean water source facility (percentage of number of family not using piped water (PAM/PDAM))
		Quality of drainage in the village/ <i>kelurahan</i> administrative area
15	Poor Family Health Insurance (0.045)	Percentage of number of household having decent sanitation facilities in village/ <i>kelurahan</i> administrative area.
		Proportion of poor community having the KIS (Healthy Indonesia Card)/BPJS

Component, Indicator, and Weight of Adaptive Capacity Dimension (Author Team, 2020)

D. Vulnerability Analysis

The vulnerability of study area toward flood and tidal flood was obtained from the multiplication function of the Sensitivity (S), Exposure (E), and Adaptive Capacity (AC). The result of the vulnerability model was then classified into 5 vulnerability index classes, from very low to very high, which result is shown spatially to provide an illustration on vulnerability level of each village/*kelurahan* in the study location.

$$V = \frac{S \times E}{AC}$$

Description:

V = Vulnerability

S = Sensitivity

E = Exposure

AC = Adaptive Capacity



E. Projection of Vulnerability Index

Considering data limitation and characteristics of all indicators being used, not all indicators in the three dimensions were projected in the process of vulnerability index projection. The non-projected indicators included those associated with:

- Community perception (from questionnaire)
- Policy elements
- Natural physical conditions that tended to be stable for a long period of time

Other indicators that were not associated with the above three conditions were projected by using statistic method and spatial dynamic with cellular automata simulation.

The spatial **dynamic** method was only used **for the land use projection process**. There were **20 indicators** used in this model, comprising:

- Existing land use;
- The driving factors comprising road network, distance from road network, transport hub, public and social facility, industrial plan spatial allocation, trade and service, beach tourism development, and centers of district/*kelurahan*/village;
- Limit of flood inundated area, limit of forest area, and limit of green area;
- Flood control infrastructure;
- Existing land use;
- Coastal line;
- Permanent inundation area;
- Weighted factors and constraints in settlement area, industrial area, inundation area land use, green area, and protection area; and
- River

2.2 | Risk Analysis Method

Risk is defined as a measure of potential damage or loss in asset/anomaly, environment, and human, which can happen when a threat becomes a reality, including the level of severity that needs to be anticipated (IPCC, 2007).

In this study, risk is a function of parameters of hazard and vulnerability. The result of risk spatial modelling is then classified into 5 index classes, from very low to very high. The risk map produced has a grid-scale analysis unit, which displays overlaid with village administrative boundary.

Although the map displayed has a grid analysis unit, in the analysis process, it will show a maximum value of the entire grid in that particular village/*kelurahan* boundary. Thus, if a village/*kelurahan* had a very high risk area (while others are very low-high), the village/*kelurahan* would still be categorized as of very high risk, since the one taken would be the maximum value. This is conducted so as not to neglect the real condition that there are parts in that particular area having higher risk than the other areas. As for the map, the display with grid analysis unit was selected to provide a spatially more detailed description, particularly for the flood-affected areas. This way, spatial and non-spatial risk analysis could be generated.

Similar to the hazard and vulnerability analysis, the risk analysis process was also carried out for baseline condition and projection to 2035 (with 5-yearly projection period). The analysis process did not only look into the trend in risk index change in the study location, but also at the potential impact of flood inundation (permanent and the farthest) to the land use in that location from spatial perspective.

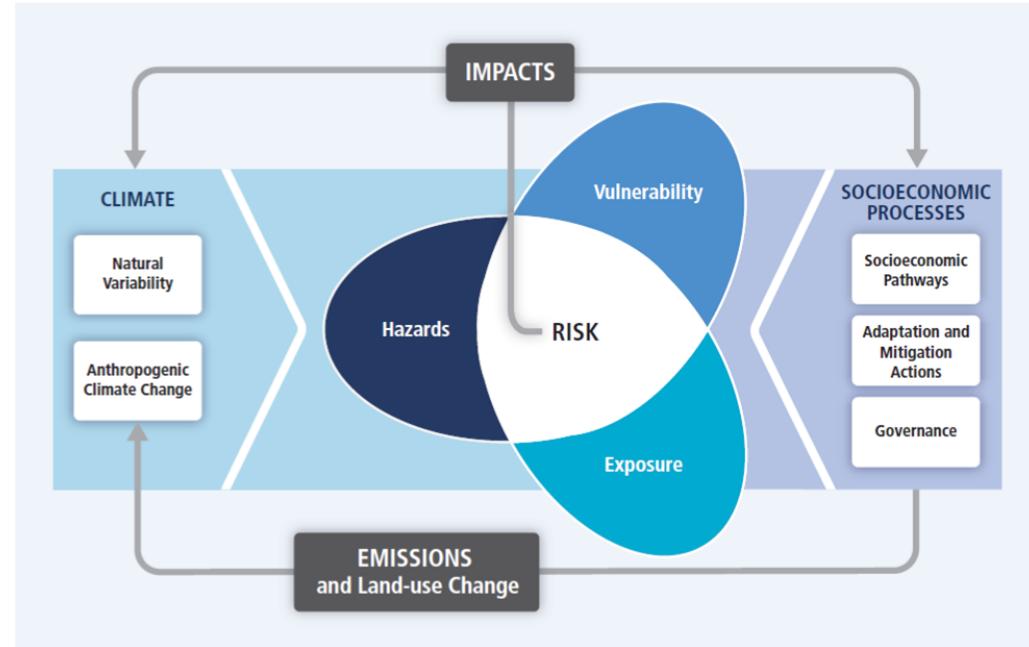


Illustration from the Core Concept of IPCC WGII AR5 which Contains Scheme on Risk Study (IPCC, 2012, 2014)

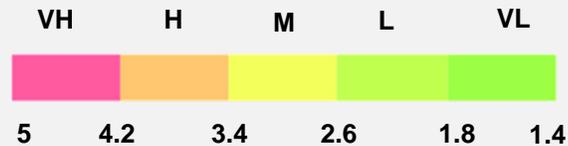
$$R = H \times V$$

Description:

R = Risk

H = Hazard

V = Vulnerability



2.5 | DTM, Land Use and Land Subsidence

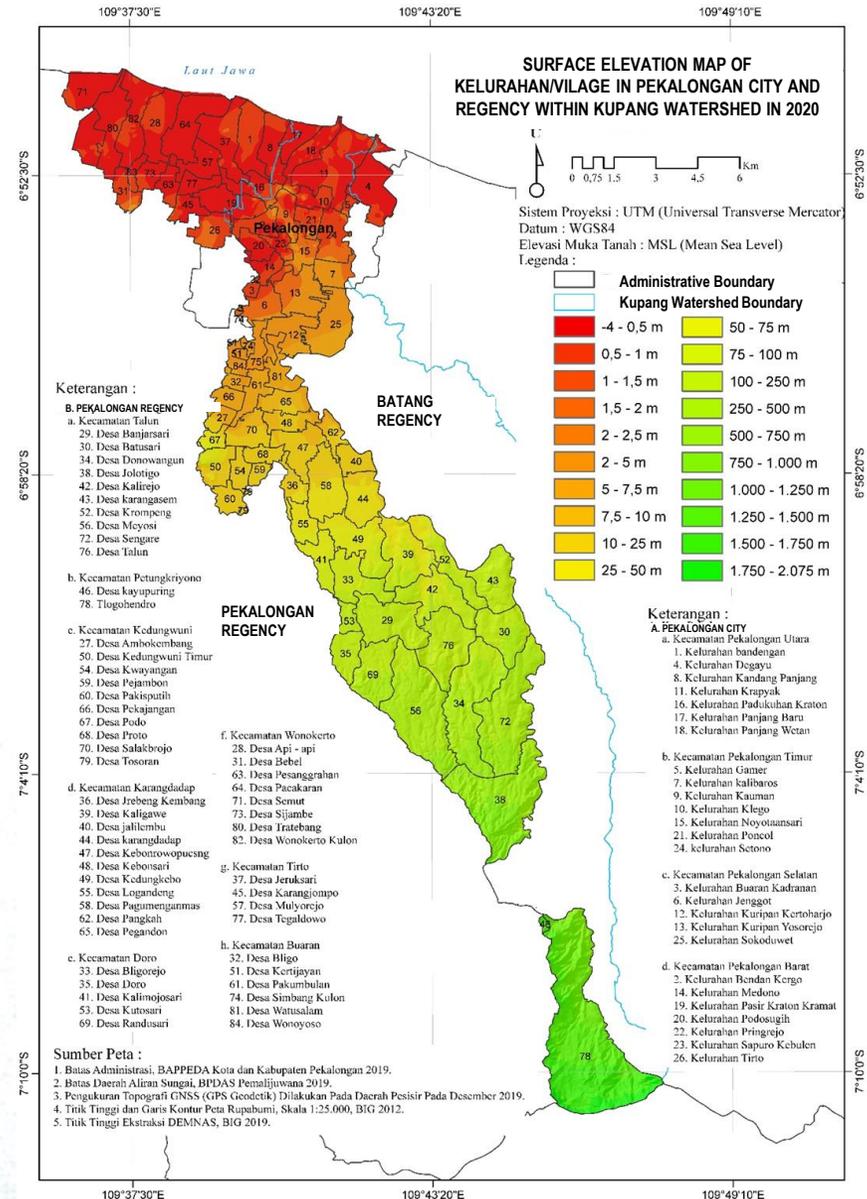
The three analyses were conducted to correct and increase accuracy from the spatial vulnerability analysis process and served as an input to the hazard analysis process.

A. Development of Digital Terrain Model (DTM)

The coastal area in the study location has very flat topography and highly influenced by the land subsidence. For spatial-based study process, particularly to analyze the coastal area, it is very necessary to have the location's topographic data with high accuracy, which currently has not been obtained yet from the secondary data. The available secondary data that are commonly used are the DEMNAS (Digital Elevation Model Indonesia). For the condition of the study location, DEMNAS did not possess sufficient accuracy and might therefore influence the study result. Thus, in this study, DTM was developed to provide more detailed spatial information.

The DTM development was initiated by mapping out the detailed land surface elevation using the Geodetic GPS instrument in a very flat area in the Pekalongan City/Regency coast, which was part of the study area. The data were then mosaiced with the DTM data formed from the topographic basic map of scale 1:25,000 to obtain the Digital Elevation Model (DEM) data of the entire study location.

The new DEM then became input data in the inundation modelling process, so that the constructed model would have higher accuracy and more representative of the study location's condition. The modeling results show that the **downstream and coastal areas have a relatively flat elevation**, yet it should be noted that there are **spots across the coastal area which elevation is lower than point 0** (even until -4 m) below surface. The areas are generally already permanently inundated. Starting from middle to upstream area, the land surface elevation becomes higher with the height range of 500-2,075 m; showing a rather high inclination in that area.



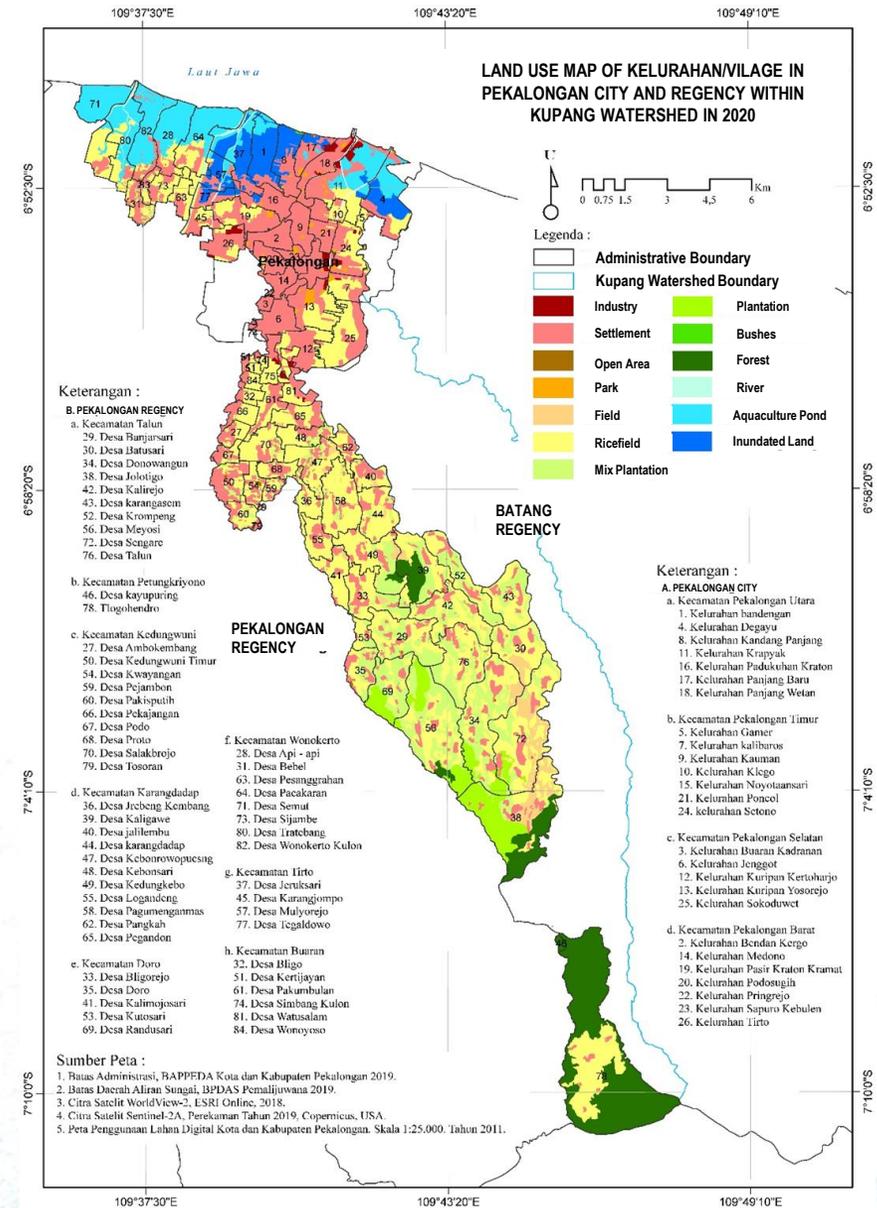
Baseline Surface Elevation Map (Author Team, 2020)

B. Land Use

The updating of land use was carried out on the last land use map of the Pekalongan Regency and City Governments, which used the Sentinel 2A high resolution satellite data in 2019 (Copernicus USA, 2019), and high resolution satellite data of World View-2 (ESRI Online Basemap, 2018). Land use from the existing digital map was reclassified by using the most recent satellite data, which was then mosaiced and split off in accordance with the study location. The most updated land use map was used to fill out the indicators of baseline condition in the analysis process and served as a basic map to conduct land use projection in every analysis period.

The land use update shows that in 2020, the majority of coastal area are fish pond and inundated, with little settlement area. For downstream area, the land use is dominated by settlement area, with little ricefield in the east and west side of the study location. As for the middle area, the dominant land use is ricefield with settlement area that are spread, yet with a relatively smaller size. The domination of productive land and protected area become more visible in the upstream area, where the types of land use constitute a mix between ricefield, combined garden, plantation, field and forest (protected and productive); with smaller settlement clusters that are spread across the area.

In the study process, a land use projection was also carried out using the *cellular automata simulation*, which is a spatial dynamic model to process the land development in serial-based from year to year. The land use projection served as the basis to conduct vulnerability dimension projection, particularly for the exposure and sensitivity components. In addition, the land use projection was also used in the risk analysis process to look at the impacts of changes in inundation size (permanent and farthest) to the land use in every period; which types of land use might be inundated, so as to ensure that the anticipative measures to be taken would be more effective. The land use projection was carried out by assuming that there was no changes in the total land size during the projection period.



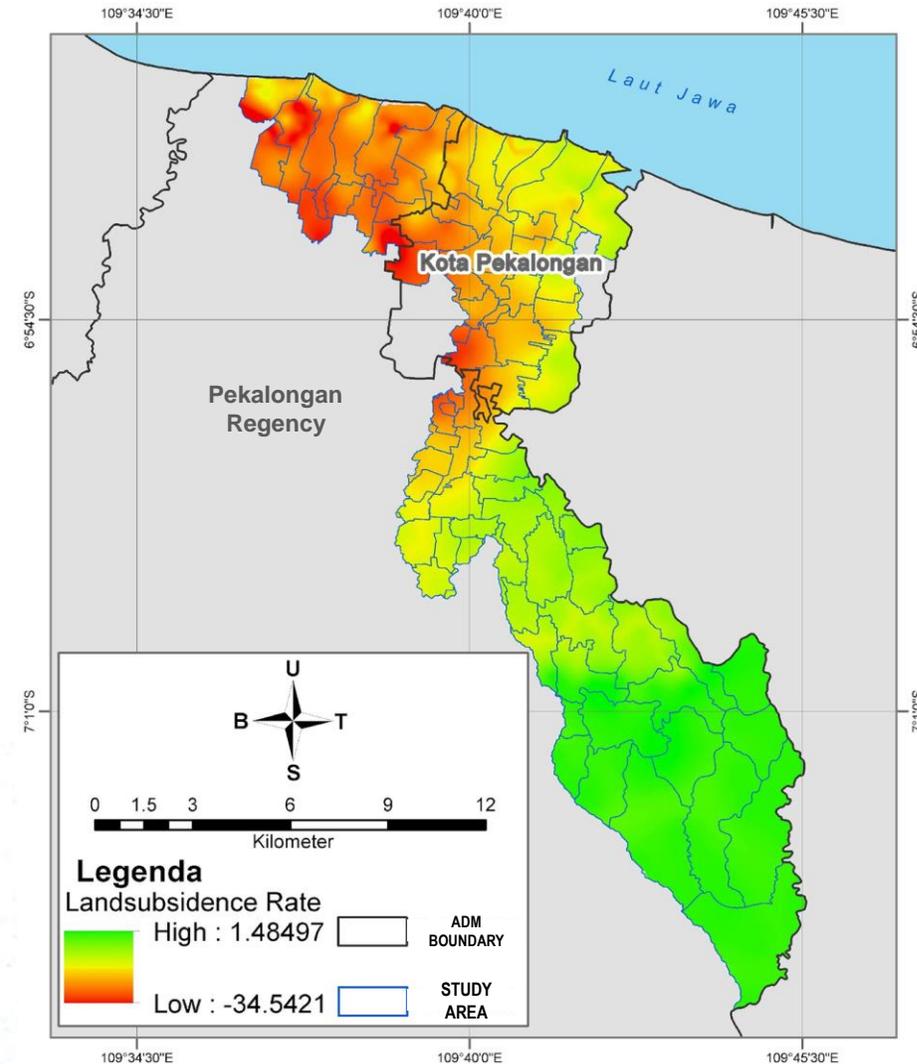
C. Land Subsidence

The data on land subsidence was needed in conducting the spatial analysis process to fill-out the data in the exposure index indicator, namely proportion (%) of area size undergoing land subsidence per village. In addition, the spatial distribution of the land subsidence was also utilized as one of the land physical factors influencing the flood modelling process in the hazard analysis, including the potential occurrence of permanent inundation.

In this study, the land subsidence data were obtained by using Sentinel-1 satellite data analysis that applied differential SAR interferometric method. The data obtained were land subsidence rate for 2019 (January-December). Throughout the study process, the rate was assumed to be constant every year (no increase nor decrease in rate).

The data processing results show that the **rate of land subsidence in the study location is relatively high**, which ranges between 0-34.5 cm/year (median \pm 16.5 cm). For **coastal area, the land subsidence rate ranges between 11-34.5 cm**. It is visible that the study location in Pekalongan Regency coast generally has higher subsidence rate than that of Pekalongan City coast. **Semut Village, Tratebang, and Pacakaran, are the three coastal villages that have spots with land subsidence rate up to 34.5 cm/year, in addition to Bebel and Karang Jompo Villages in the downstream area.**

As for Pekalongan City, the highest land subsidence rate takes place in Kelurahan Tirto (i.e. up to **34.5 cm/year**), **Jenggot, and Buaran Kadranan**. The relatively higher land subsidence in Pekalongan City generally takes place in the downstream area and locations bordered with Pekalongan Regency.



. Map of Land Subsidence Rate of 2019 (Author Team, 2020)

Another noteworthy aspect is the relatively high land subsidence in **the central area**, where there are locations with **land subsidence ranging from 11-23 cm/year**. These numbers, however, are still below those of the downstream and coastal area. However, the land subsidence trend in the middle area still needs to be anticipated.

Throughout the study process, the data were also spatially and non-spatially compared with other study results in Pekalongan area. The study conducted by ITB Geodesic Team suggested that the coastal area and downstream area of Pekalongan City experience average land subsidence of 1-10 cm/year in 2012-2018 study period; furthermore, various spots were also found with the land subsidence rate of 15-20 cm/year within certain time interval. Another study by Kemitraan suggested that the land subsidence rate from 2015-2017 in the coastal area and downstream area of Pekalongan City ranged between 11-30 cm (achieving 34 cm in certain spots) and became smaller down-south, with land subsidence predominantly took place in the eastern part.

Spatially, it can also be seen that both research and study results show a relatively similar spatial distribution of land subsidence rate. However, in 2019, the study results show that land subsidence area became wider, particularly heading west and southward, thus no longer dominant in the east part. Spatial and non-spatial perspectives-wise, it can be seen that the land subsidence data in this study are relatively in harmony with the historical data from other studies. It is noteworthy, however, that the two studies have not passed through the field correction step like that which has been conducted in this study.



2.6 | Impact Analysis of Economic and Non-Economic Loss

Analysis on the impact of economic and non-economic loss is a process of estimating and assigning monetary value on economic and non-economic losses from flood risk. The economic valuation as a monetary indicator itself will depend on how society responds to and accepts the changes that occur (Putri *et al.*, 2007).

Considering that flood event in the Kupang watershed has become a recurring event for a long period of time with an ever-increasing intensity, a micro-scale analysis process that involves the most affected communities as the subject is deemed as critical to be done since they have specific characteristics that differentiate them from the other general community groups (Geest *et al.*, 2017). Therefore, the geographical scope for impact analysis of economic and non-economic loss under this study is the area with high and very high risk level based on risk analysis results (both baseline and projection condition). There are 42 villages/kelurahan across 7 sub-districts within Pekalongan City and Pekalongan Regency administrative area that were assessed as a high and very high risk area, and they will be referred to as the hotspot area. The primary data collection process for the analysis involves 289 respondents in 42 villages/kelurahan.

Three sub-analysis were conducted as part of this particular impact analysis, namely: analysis of community risk characteristics and perception, analysis of Livelihood Vulnerability Index and analysis of the value of economic and non-economic loss; where the first two sub-analysis will provide an overview of the socio-cultural impacts experienced by the affected communities.

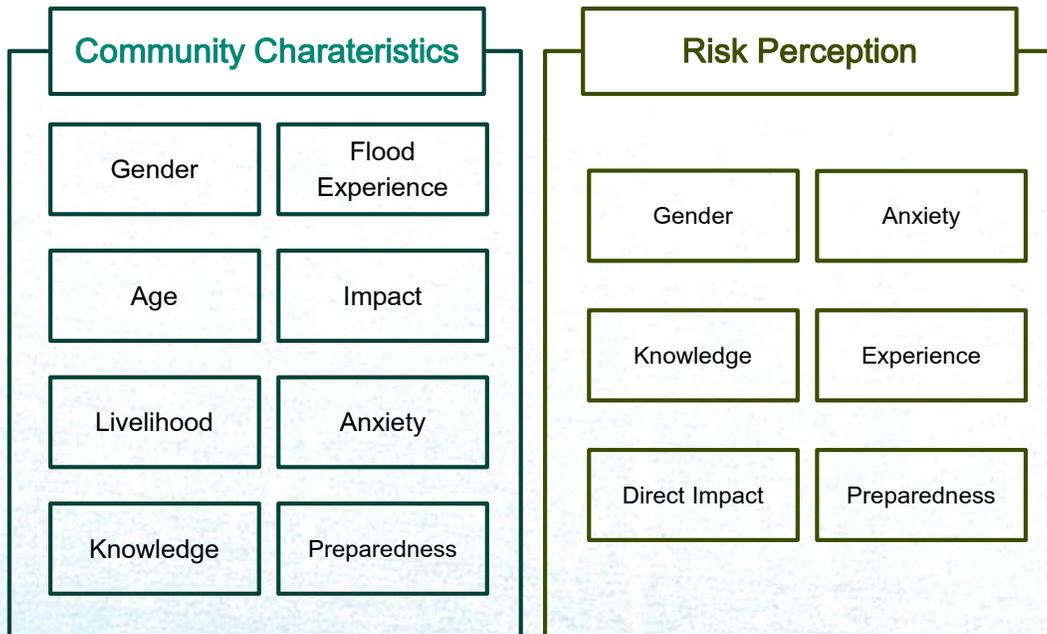


Economic and Non Economic Analysis Process (Author Team, 2020)

A. Community Risk Characteristics and Perception

The risk perception analysis in this study is a subjective analysis regarding the perception of the affected communities on flood risk (and the related aspects). Due to this subjective nature, risk perception will be built upon individual intuition, personal awareness, personal experience, immeasurable losses, individual factors, and individual actions of the affected communities. This risk perception will help in determining the appropriate risk management scheme to be implemented in the community. Identification and analysis of community characteristics in the 42 hotspot areas initiates the risk perception analysis process by providing information related to the profiles and cultural characteristics of the local community.

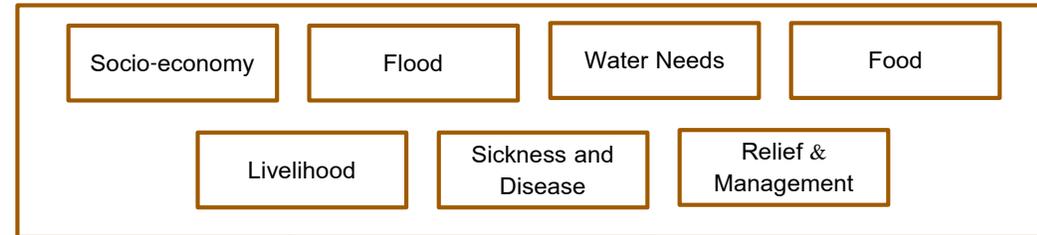
Components of Community Risk Characteristics and Perception Analysis



B. Livelihood Vulnerability Index (LVI) Analysis

LVI analysis will provide a systematic overview of the interaction between humans and the physical and social environment by examining components: socio-demographic profiles, livelihood strategies, social networks, health, food, water, housing and land tenure, and natural disasters (Shah et.al., 2013), In this study, adjustments were made to the components and sub-components used in the LVI analysis process by taking into account the local context and data availability (Appendix M).

Components of LVI Analysis



LVI Calculation Steps:

i) Calculation of Sub-Component Index:

$$Index_{sd} = \frac{Sd - Smin}{Smax - Smin}$$

* *Index SD = sub-component index; Sd= sub-component; Smin = minimum value; and Smax = maximum value*

ii) Calculation of Component Value:

$$M_d = \frac{\sum_{i=1}^9 index_{sd}}{9}$$

* *Md= component standarization ratio; index Sd= sub-component index; and i = sub-component*

iii) LVI Calculation (each location)

$$LVI_d = \frac{\sum_{i=1}^9 wmi \cdot Mdi}{\sum_{i=1}^9 wmi}$$

* *LVI_d = LVI of the affected location; wmi = component; Mdi = component value; and i = sub-component*

- **LVI Value Range:** 0 (Not Vulnerable) until 0,50 (Very Vulnerable).
- The same value weighting is used for all components and sub-components

C. Economic and Non-Economic Loss

Analysis of the economic and non-economic loss is a monetary valuation approach for economic and non-economic losses caused by flooding event in hotspot areas. The analysed data was obtained from questionnaire data from 289 respondents in 42 villages/kelurahan. There are 4 (four) losses components that are taken into account in this analysis, namely: i) Material losses; ii) Non-material losses; iii) Agricultural land productivity; and iv) Ecosystem services. The calculation is carried out for both the baseline year (2020) and the projected year (2035).

I) Material Loss

Material loss aspects that were taken into account include: adaptation costs to continue stay in the affected area; repairment cost; medical cost; additional costs for water, food, electricity; waste handling costs; as well as decreased income and increased business cost.

- The calculation method for adaptation cost, repairment cost, medical cost, additional cost (water, food and electrical energy) and waste handling cost is approached by using the following equation (Rosemarry, 2014):

$$RBP_b = \frac{\sum_{i=1}^n BPb_i}{n}$$

* RBP_b = average annual expenses (Rp/year/HH); BPb = expenses value (Rp/year); and i = Respondent number- i (1,2,3, ... number- n)

- The adaptation cost is determined by: the number of flood events, flood height, the area and type of housing structure, and also housing density in an area
- The real value of adaptation cost, repair cost, medical cost, additional cost and waste handling cost incurred in the year the damage occurred is converted to the current value by using the interest rate of the Bank of Inoonesia in 2019 as the reference point.

- The calculation method for the loss of income due to not carrying out economic activities (as a result of the flood event) follows the equation below (Dhewanthi et al., 2007):

$$P = \frac{\sum_{i=1}^n JHTKI \times PRi}{n}$$

* P = individual loss of income; $JHTKi$ = number of days of not conducting the activities; PRi = daily income of respondent number- i ; and i = respondent number- i (1,2,3, ... number- n)

- The calculation for the increase in business costs is done by considering the additional capital for re-investment and working capital for agricultural and aquaculture activities on the affected land.

II) Non-material Loss

The non-material losses that were taken into account are psychological/mental disorders and domestic violence.

- Flood events can cause psychological effect to the community such as stress at various levels. The quantification of the value of non-material losses for mental disorders is carried out by referring to the IASC 2007: 12 for service fees and Minister of Health Regulation No. 69 of 2013 concerning Standard Tariffs for First Level and Advanced Level Health Services in the Implementation of the Health Insurance Program. The utilized value for the calculation is the average cost (rounded up) to cover room costs and other actions.
- Stress levels that are too high due to flooding can affect the household mentality which could then result in domestic violence. The quantification for loss due to this domestic disturbance is carried out by referring to the fine imposed for each level of disturbance as stated in the Domestic Violence Law (UU 23/2004).

iii) Agricultural Land Productivity

Taking into account the type of the affected productive land type, monetary value calculation for the loss of productive land was then conducted only for agricultural land and aquaculture area :

- The affected agricultural land in the hotspot area is generally used for rice fields or secondary crops. The approach to determine the decrease in agricultural land productivity is done by considering the annual loss of profit that should have been provided by the agricultural land due to the loss of the said land (from flooding). The profit of agricultural land itself is calculated by taking into account: annual productivity of ricefield, average selling price and production costs; where the value used is determined based on the interview results and literature studies.
- The affected aquaculture in the hotspot area is generally used for the cultivation of milkfish and tilapia, either using monoculture or polyculture system. Traditional aquaculture method is not a rare sight in the hotspot area, and this method is often seen being applied in aquaculture land that are affected by flood. The calculation to determine the decline in aquaculture land productivity is done by considering the annual loss of profit that should have been provided by the aquaculture land that applies traditional method due to the loss of the land (from flooding). The assumptions used to determine the advantages of traditional ponds were obtained from interviews with respondents and literature studies.

iv) Ecosystem Services

Considering the data availability to have an accurate calculation, the economic loss for ecosystem services due to flooding in this analysis process is only approached from the disturbance in cultural function of the affected ecosystem, namely the recreational function. Therefore, the economic loss will be seen from the calculation of recreation costs of the community in the hotspot area.

Recreation cost value is generated using the Travel Cost Method (TCM). TCM is an indirect measurement method for goods or services that have no market value (non-market good or service), such as tourism objects/sites. In this method it is assumed that visitors to a tourism site incur or bear economic costs, in the form of travel expenses and time to visit a place (Lipton DW et al., 1995).

TCM Calculation Stages:

- i) Clustering of socio-economic descriptive data for visitors or in this case the affected communities, including travel costs
- ii) Determination of the derived demand for tourist visits from certain areas by regressing on variables that are considered to have an effect on the number of visits, namely travel costs (TC), income (Y) and travel costs to the alternate tourism sites (S); where the distance will affect the amount of travel costs.

$$\ln V_{ij} = \beta_{0j} - \beta_{1j} \ln TC_{ij} + \beta_{5j} \ln Y_{ij} + \beta_{4j} \ln S_{ij}$$

* V_i = visit trip of individual i from zone j ; TC_{ij} = travel cost of individual i that comes from zone j ; Y_{ij} = income of individual i that comes from zone j ; and S_{ij} = travel cost to the alternate tourism site of individual i that comes from zone j

- iii) Determination of consumer surplus (CS) by considering the total utility of the resources utilized (U) and the total of the average travel cost of each zone (TC_{total}). The utility cost is an integral of the demand function in the form of the number of visits.

$$\begin{aligned} V_i &= \beta_o * TC^{\beta_i} \\ U &= \int_0^{\infty} f(V_i) dV_i \\ CS &= U - TC_{total} \end{aligned}$$

D. Projection Methods

The projection of economic and non-economic losses in the hotspot areas is carried out for the period of 2020 to 2035 with a 5-year analysis range. Three scenarios were used for the projection:

- i) **Scenario 1** : based on the existing landuse data in 2020 that overlaid with flood modelling simulation results in 2020, 2025, 2030 and 2035
- ii) **Scenario 2** : based on land use change projections (dynamic modeling with cellular automata) that overlaid with flood modelling simulation results in 2020, 2025, 2030 and 2035.
- iii) **Scenario 3** : based on the spatial pattern outlined in the Spatial Plan of Pekalongan City and Regency that overlaid with flood modelling simulation results in 2020, 2025, 2030 and 2035.

The basis for the projection calculation are as follow:

- ❖ The value of future losses is calculated based on the concept of time of value.
- ❖ The future value calculation uses a discount rate of 4.44% per year. This value refers to the average annual inflation rate in the study area in the last 7 years (2013-2019).
- ❖ The projected population of the affected community is calculated exponentially by considering the average rate of population growth per year.
- ❖ Projection of flood area distribution for each village/kelurahan area according to the projection time period.
- ❖ The calculation of the proportion of the area in each village/kelurahan that is exposed to flooding is used as the basis for the simulation of the projected value of economic and non-economic losses.





Bab 03.

HAZARD ANALYSIS

3.1 | Climate Scenario

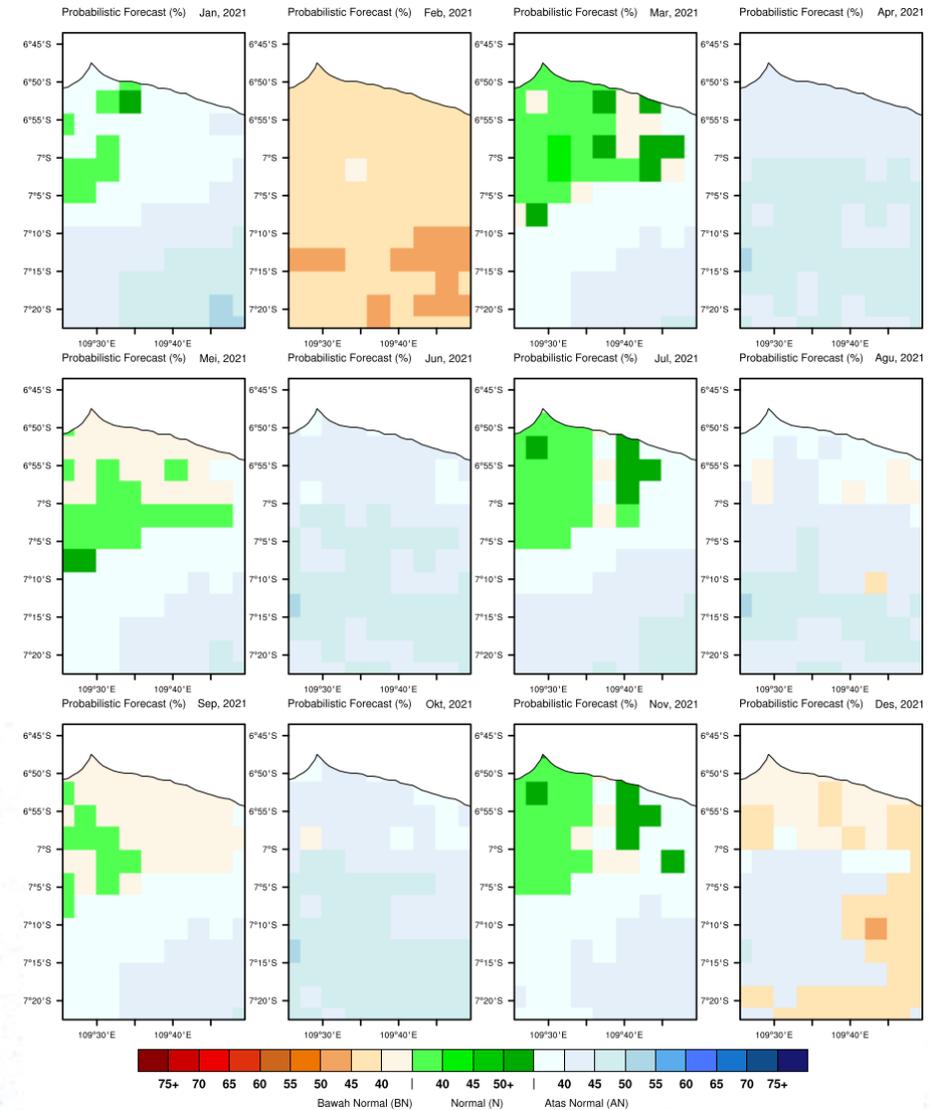
A. Decadal Climate Prediction

The probability of the monthly rainfall anomaly and the value and trend of wet extreme index are two aspects being analysed in the decadal climate prediction for 2021-2035.

The analysis of probability of monthly rainfall anomaly shows the tendency of domination of Above Normal (AN) rain anomaly. As an example, AN rainfall in 2021 is predicted to take place more frequently in study location, except for February and December, particularly in the upstream and middle areas. Meanwhile, downstream and coastal areas in the same year shows the dominant tendency of Normal (N) rain anomaly. The dominant AN rain prediction was also found for the following years, with different spatial values and distribution characteristics.

The tendency of probability of more rain taking place in upstream area can be one of the indications of the need for a more comprehensive watershed system management that covers the entire parts from upstream to downstream. Upstream management must be focused on reducing runoff reaching the middle and downstream areas. This will ensure that the runoff passing through the downstream or coastal areas will not exacerbate the flood in those areas, particularly when the rains came together with the tide, which in turn would lead to tidal flood.

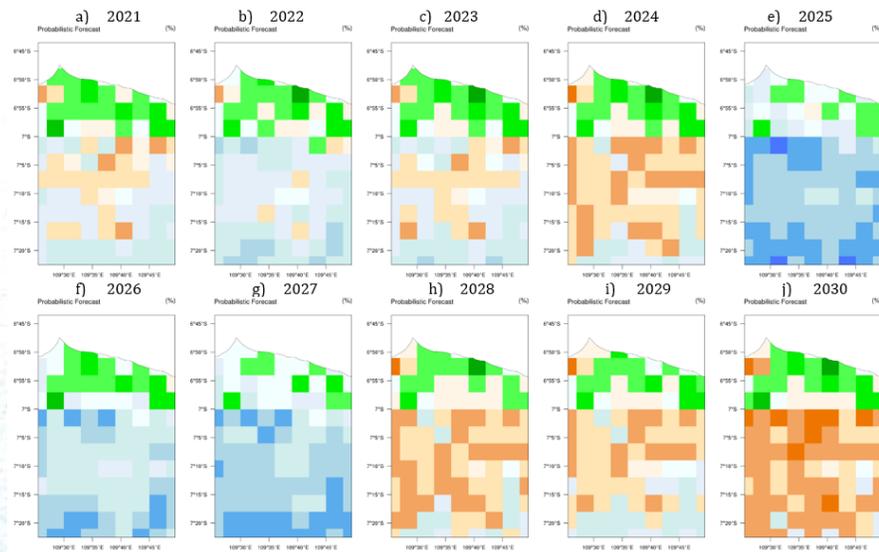
Wet extreme index that was analysed under the decadal climate prediction comprise of: 1) **Rx1day**, which is the highest daily rainfall within 1 year; 2) **Rx5day**, which is the highest 5-daily cumulative rainfall in 1 year; and 3) **R20mm**, which is the number of rainy days in a year with daily rainfall value of more than 20 mm.



Decadal Climate Prediction - Probability of Monthly Rainfall anomaly for the Period of January-December 2021 (Author Team, 2020)

The historical and prediction data show the indication of decreasing amount of maximum annual daily rainfall intensity. The Rx1day prediction in the coastal area generally ranges between 60-70 mm, while that in the upstream area ranges between 80-90 mm. The Rx1day enhancement in the coastal area was predicted to take place in 2032-2034 with value range of 90-100 mm. From event probability side, the decadal prediction shows **dominant tendency of AN for Rx1day, with higher probability in upstream than downstream and coastal area.**

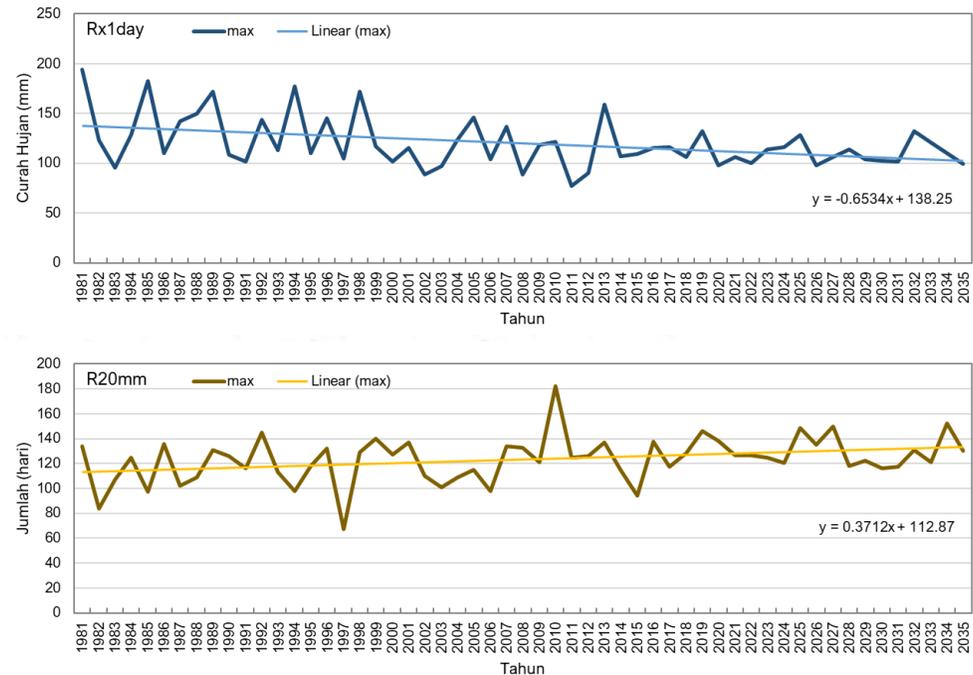
Similar to Rx1day, generally the prediction shows a decrease in Rx5day data variability as compared to that of historical condition. The prediction value for Rx5day in the coastal area tends to be stable with ranges between 160-180 mm, while in the upstream area it is predicted to increase in 2025 with the average value of 240 mm. From event probability side, **the dominant AN category probability was found more frequently in the upstream and downstream areas as compared to the middle, with domination area not as wide as the probability prediction of Rx1day index.**



Prediction on the possibility of Wet Extreme Index anomaly of R20mm for 2021-2030 (Author Team, 2020)

Oppositely with Rx1day and Rx5day, for R200mm, there is **a tendency of increasing intensity of the prediction data** and location differences with tendency of AN probability domination. The probability prediction shows that **the AN condition has higher tendency to take place in upstream and middle areas**, while N condition potentially dominates the coastal area. Intensity-wise, the R20mm value is predicted not to experience any trend changes in the coastal area, which ranges at 60 days value, while the one in the upstream area is predicted to increase in 2025 and 2034 with average value of 130 days.

In general, the decadal climate prediction indicate **the possibility of decreasing intensity of wet extreme index, yet with an increasing number of wet extreme events.**



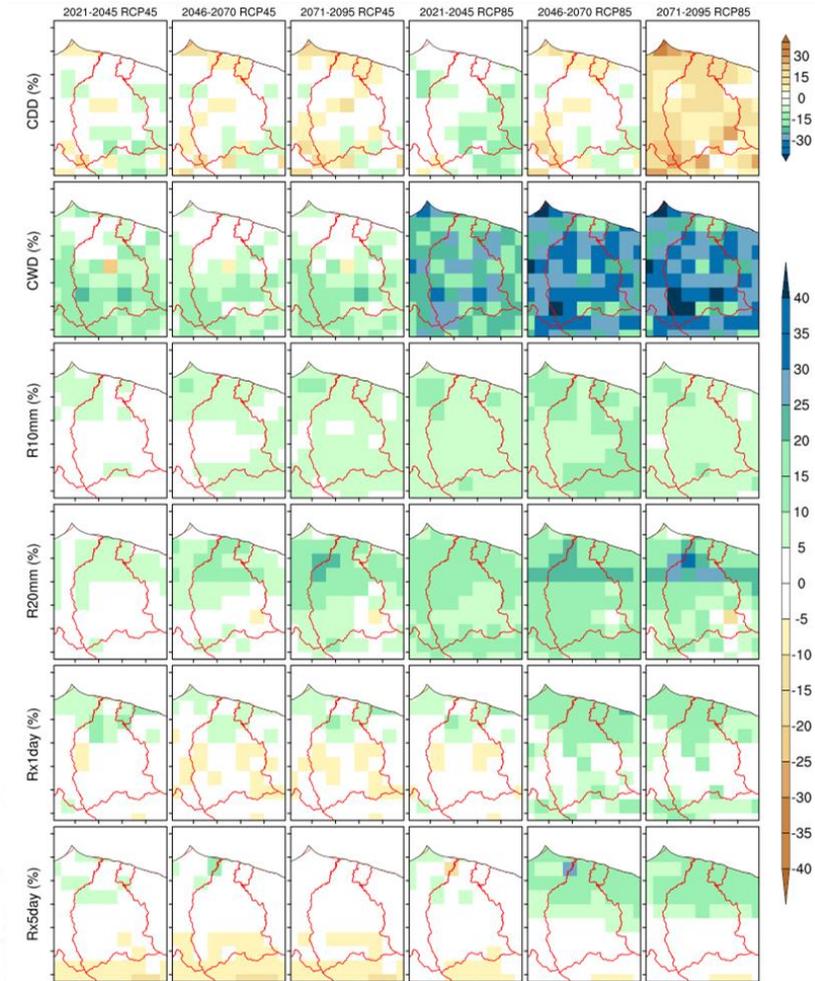
Historical Trend and Decadal Prediction of Rx1day Wet Extreme Index (above) and R20 mm (below) (Author Team, 2020)

B. Long-term Climate Projection

The long-term climate projection was carried out for two scenarios, namely 1) RCP 4.5 which represents moderate condition with moderate mitigation measures scenario to maintain radiative forcing level, and 2) RCP 8.5, which represents extreme condition with scenario of no measures conducted to limit the green house gas emission. The period used for the long-term climate projection is 2021-2095.

The **extreme index** analysed in this project was **Consecutive Dry Days (CDD)**, **Consecutive Wet Days (CWD)**, **R10mm**, **R20mm**, **Rx1day**, and **Rx5day**. The **Rx1day**, **Rx5day**, and **R20mm** indices are the reference for wet extreme condition that is strongly interlinked with flood and landslide events. Meanwhile, CDD represents the dry extreme condition as it provides information on the longest period of a day without rain consecutively within certain period of time, hence very identical with drought.

The long-term climate projection results indicates that the **study location will experience wetter condition**. Spatial analysis shows an **increase of intensity percentage and frequency of extreme rainfall events particularly in coastal area**, as identified by the increase of percentage of changes of Rx1day, Rx5day, R10mm, and R20mm indices. Specifically for RCP4.5, the decrease of percentage of Rx1day and Rx5day indices in upstream area tends to be larger and wider than the increase of percentage in downstream area. The **CWD index projection strengthens the possibility of wetter area condition with longer rainy day row**, where in RCP8.5 scenario, the percentage increase is projected to be >40%. On the other hand, the dry day row represented by the CDD value shows a **not really significant change of percentage** in the future.

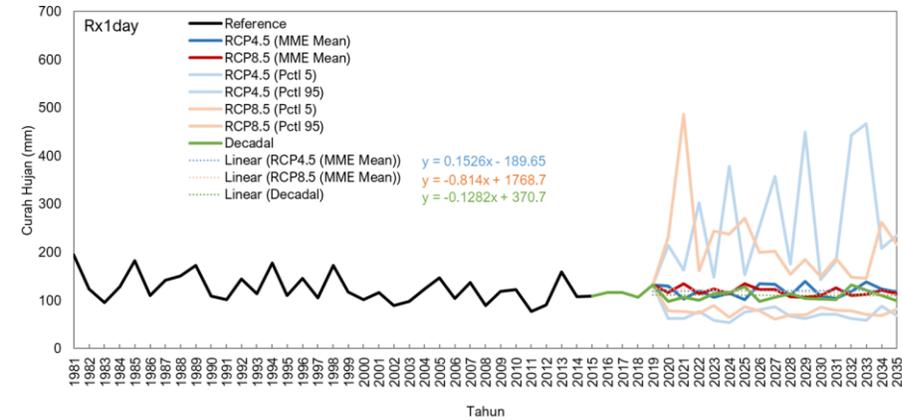


The Percentage of Changes in Extreme Index of Long-term Climate Projection (Author Team,

C. Range of Uncertainty

The climate modelling process was highly influenced by and strictly associated with uncertainty aspect. The two climate modelling processes in the study, namely the decadal climate prediction and long-term climate projection were not carried out to compare the results of both modelling processes, but rather to be used to identify the range of uncertainty of the simulation results.

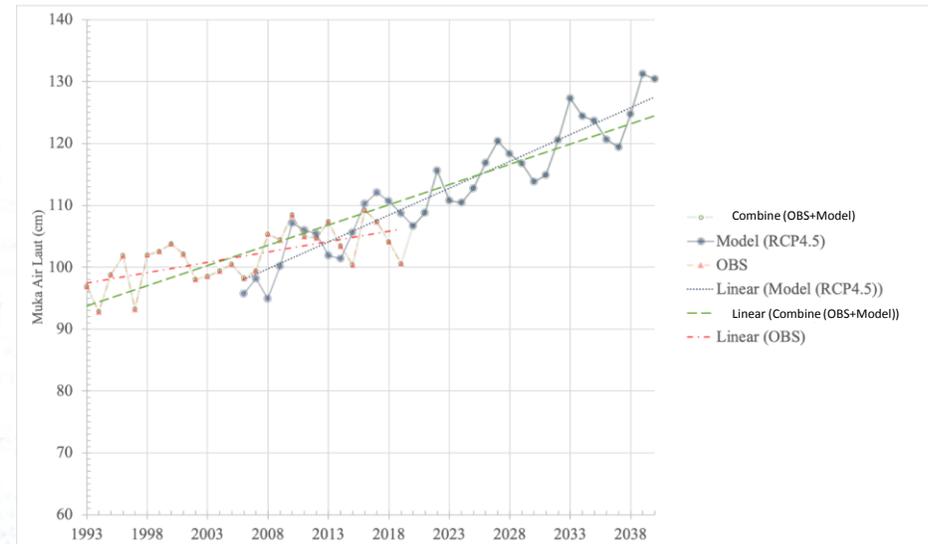
The trend analysis for the same period of data prediction/projection (period of 2021-2035) from the decadal and long-term predictions show an agreement with regard to Rx1day trend, namely the decreasing trend between decadal prediction and RCP8.5 scenario, with respective decrease rate of 0.13 and 0.81 mm/year. A different trend is shown by RCP4.5 scenario, which shows an increase rate of 0.15 mm/year. The trend's direction and rate from the relatively shorter data range (period of 2021-2035) might be different with that which will be produced using longer data (period of 2021-2095).



The range of uncertainty is represented by the value of 5th percentile and 95th percentile from each MME for RCP4.5 and RCP8.5 scenarios (Author Team, 2020)

3.2 | Sea Level Rise

The sea level rise for Pekalongan area is projected to take place until 2040. The combined results between observation and output of RCP4.5 model show the **sea level rise in this area ranges around 0.81 cm/year with $R^2 = 0.8341$** . The increase value is consistent with the results indicated in the Indonesia Third National Communication Report of 2017. The increase rate is higher than the average increase rate in Java Sea, which is 0.39 cm/year. With such an increase rate, the sea level value in Pekalongan water will reach 130 cm value by 2040.



Projection of Sea Level Rise in Pekalongan Area (Author Team, 2020)

3.3 | Inundation Modelling

The inundation modelling was conducted by using the extreme values of each input. With regard to runoff, the data used were the maximum Rx1day data in each grid that are obtained from the decadal prediction calculation, and 95th percentile value for RCP4.5 and RCP8.5 scenarios. For tidal flood, the data used were the 90th percentage of tidal water level during observation period. For land subsidence, the data used were those from 2019 analysis that assumed constant decrease rate over time. The decadal prediction data were used to show the possibility based on natural factor influence to the climate variability within yearly and decadal period. Meanwhile, the 95th percentile value of RCP scenario was aimed at representing the most severe possibility of the uncertainty range produced by the model in each scenario.

The simulation was conducted by looking at the situation during tide and extreme rain to incorporate the interaction between rain water and sea water. Other than rain data input, the rain water-sea water interaction also served as a differentiating factor between decadal prediction simulation with RCP4.5 scenario projection.

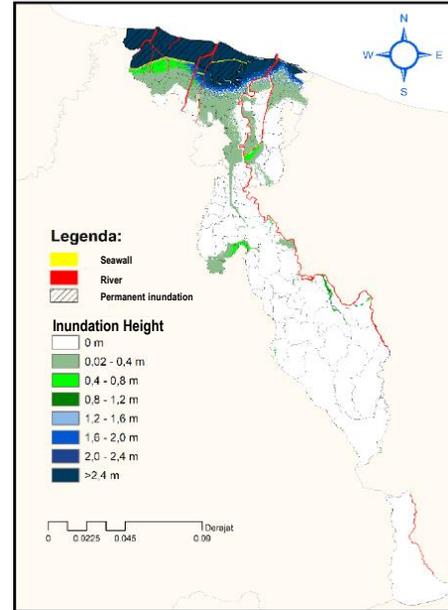
The inundation spatial model developed was divided into three groups, namely the total flood inundation model, which is the combination between tidal flood and flood due to extreme rain (rain flood), and a separate model for each tidal flood and rain flood.

A. Observation Period (2015-2019)

The inundation model simulation during the observation period served as the baseline to compare the outputs of prediction/projection results model with that of existing condition. The land elevation data used for this period's simulation were the corrected DTM of 2020, while for extreme rainfall, the data used were the maximum Rx1day value from 2015-2019 period.

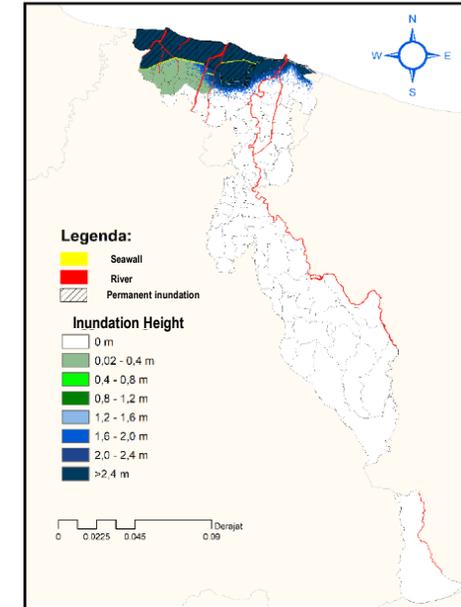
Inundation Level (Total Flood)

Observation (2020)



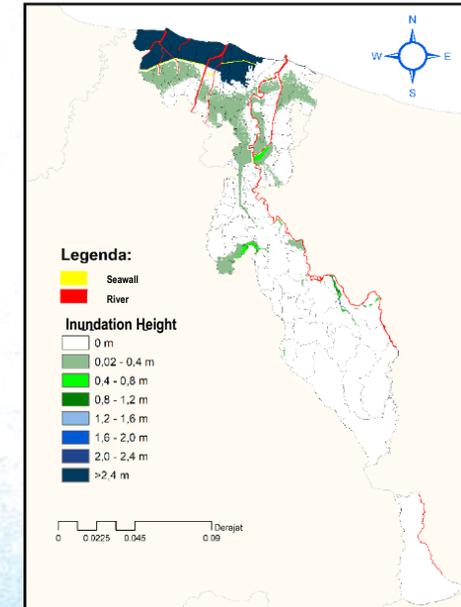
Inundation Level (Tidal Flood)

Observation (2020)



Inundation Level (Rain Flood)

Observation (2020)



During observation period, the total inundation height in the coastal area was dominated by tidal flood, whereas in coastal area that is directly bordered with the sea, the inundation might reach up to >2m high. Fairly high inundation (up to 0.8 m) were also found in the middle area such as Pakisputih, Pejambon, and Kuripan Yosorejo.

For areas located far from the coast, inundation occurrence is predominantly caused by flood due to extreme rain.

B. Inundation Modeling of 2021-2035

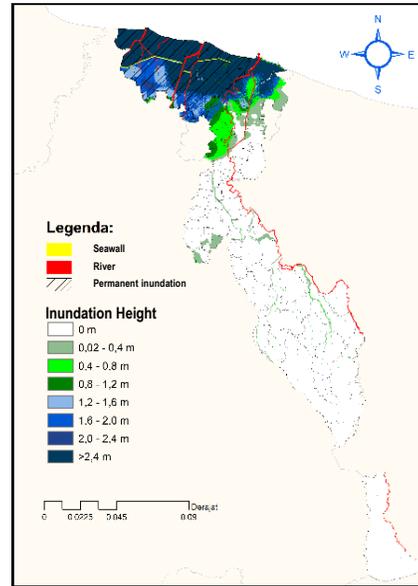
By including the sea level rise factor, constant land subsidence rate, existing land use and changes in rainfall intensity, the simulation shows that the inundation area will be broader in every projection period. In general, the discrepancy between RCP 4.5 and decadal simulation is more significantly visible in the inundation area caused by the flood.

The model simulation results show that the height of rain flood inundation ranges between 0-0.4 m and does not experience any significant changes spatially in various periods of time. **The highest increase of rain flood inundation occurs in several grids in the east and central areas** (such as Klego, Poncol, Wonokerto Wetan). In the periode of 2026-2030 the inundation will reach Pakisputih and Kalilembu with inundation height that will range between 0.8-1.6 m, **yet the affected area will be relatively small**. In middle area, there are also **areas sandwiched by tidal flood and flood, such as Klego, Poncol, and Wonokerto Wetan**.

A more significant increase in inundation size and height was found in the tidal flood simulation, which was concentrated in **the coastal area**. The inundation model simulation in various periods show the increase of inundation height until reaching >2.4 m by the end of projection period, with expanding inundation area

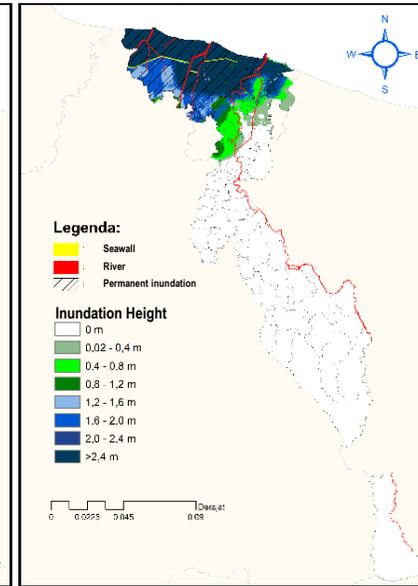
Inundation Level (Total Flood)

Decadal Prediction (2021-2025)



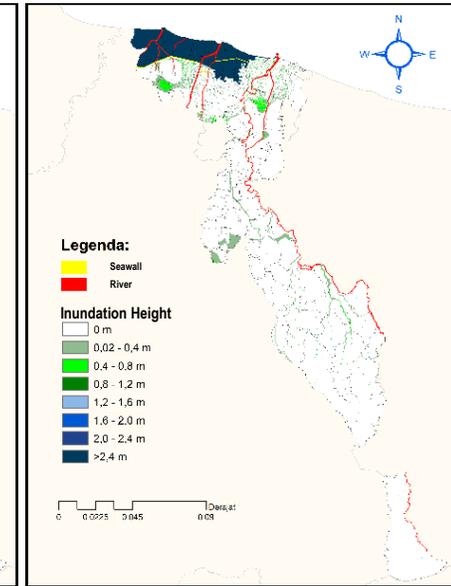
Inundation Level (Tidal Flood)

Decadal Prediction (2021-2025)



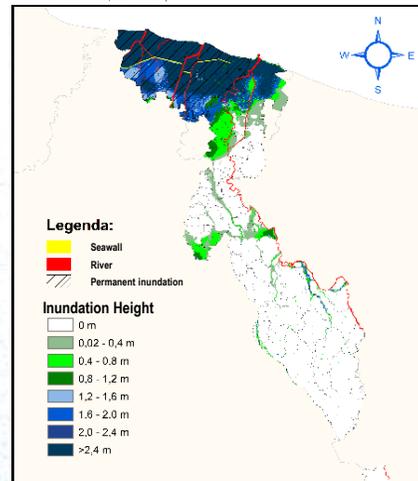
Inundation Level (Rain Flood)

Decadal Prediction (2021-2025)



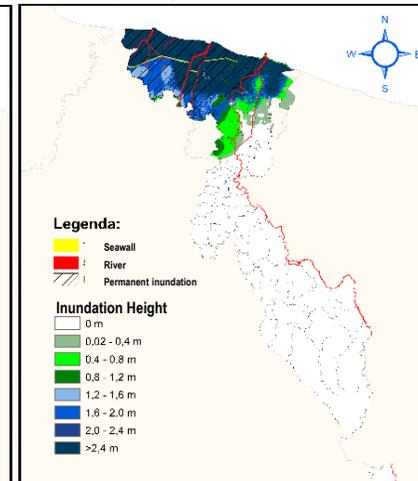
Inundation Level (Total Flood)

RCP 4.5 Scenario (2021-2025)



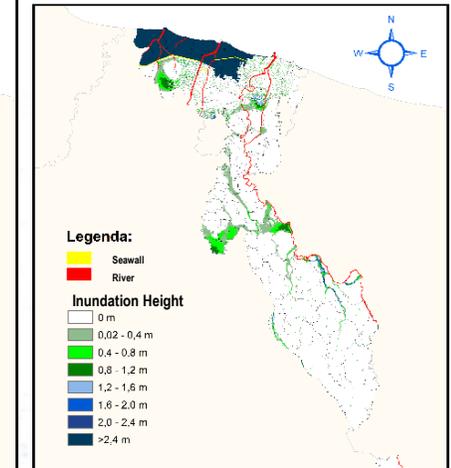
Inundation Level (Tidal Flood)

RCP 4.5 Scenario (2021-2025)



Inundation Level (Rain Flood)

RCP 4.5 Scenario (2021-2025)



Simulation of Inundation Model for the Period of 2021-2025 for Decadal Prediction (above) and RCP 4.5 (below)
(Author Team, 2020)

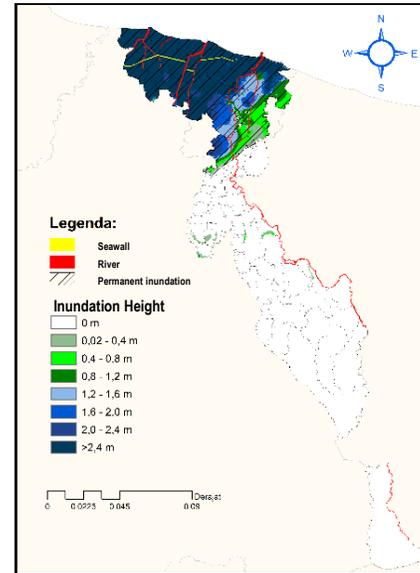
In the period of 2021-2025 (image in page 21), **inundation with height of >2 m are predicted to expand down south from the coastal area, and will expand also toward the east** (Degayu, Gamer, Setono, Klego, and Kauman, with inundation's height reaching 1.2 m) in the period of 2031-2035 (side image). The inundation near the coast is dominated by tidal flood.

Rain flood that occurs at or almost at the same time with tidal flood might exacerbate the inundation condition in the east area, with potential inundation's height achieving 2 m. The permanently inundated areas are also predicted to expand in every period. The expanding permanent inundation is caused by the expansion of areas with elevation lower than the average sea level in the study location.

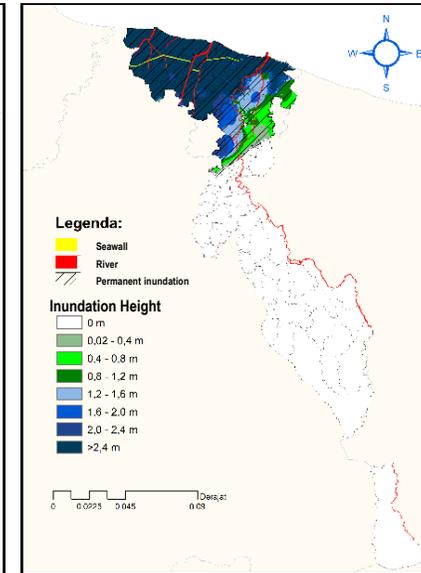
By taking into account the changes in size and height of the inundation in every projection period, **some areas that potentially experience significant inundation increase are, among others:** Tirto, Pasir Kraton, Padukuhan Kraton, Karang Jompo, Tegaldowo, Bebel, Pesangrahan, Sijambe, and Wonokerto Wetan. Meanwhile, other areas that need to anticipate inundation increase in the future include Sapuro Kebulen, Bendan Kregon, Medono, Podosugih, Pringrejo, Buaran Kradanan, Jenggot, Gamer, Kauman, Klego, and Poncol.

From the event's influence side, in various projection periods it can be seen that the **inundation formation tends to be influenced by tidal flood rather than rain flood. However, rain flood might exacerbate the inundation in an area.**

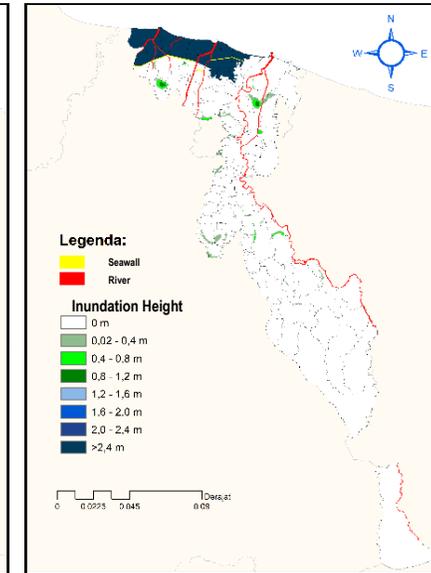
Inundation Level (Total Flood)
Decadal Prediction (2031-2035)



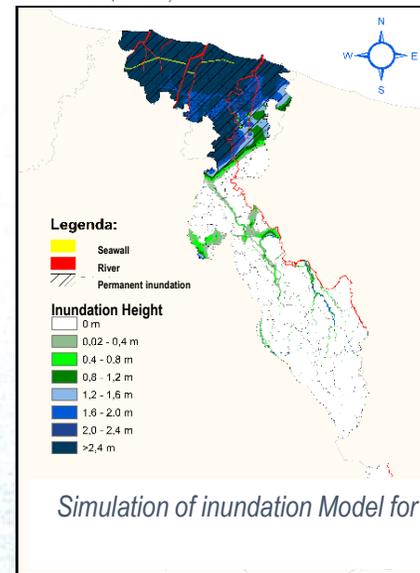
Inundation Level (Tidal Flood)
Decadal Prediction (2031-2035)



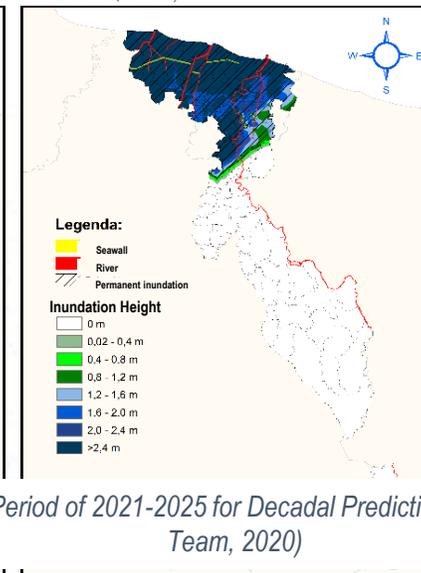
Inundation Level (Rain Flood)
Decadal Prediction (2031-2035)



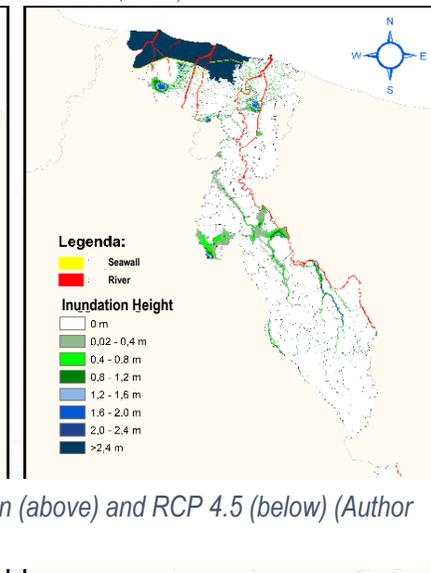
Inundation Level (Total Flood)
RCP 4.5 Scenario (2031-2035)



Inundation Level (Tidal Flood)
RCP 4.5 Scenario (2031-2035)



Inundation Level (Rain Flood)
RCP 4.5 Scenario (2031-2035)



Simulation of inundation Model for Period of 2021-2025 for Decadal Prediction (above) and RCP 4.5 (below) (Author Team, 2020)

3.4 | Hazard Modeling

The hazard index value was formulated by classifying the inundation's height in the study location into 6 classes, starting from the non-affected to very highly affected.

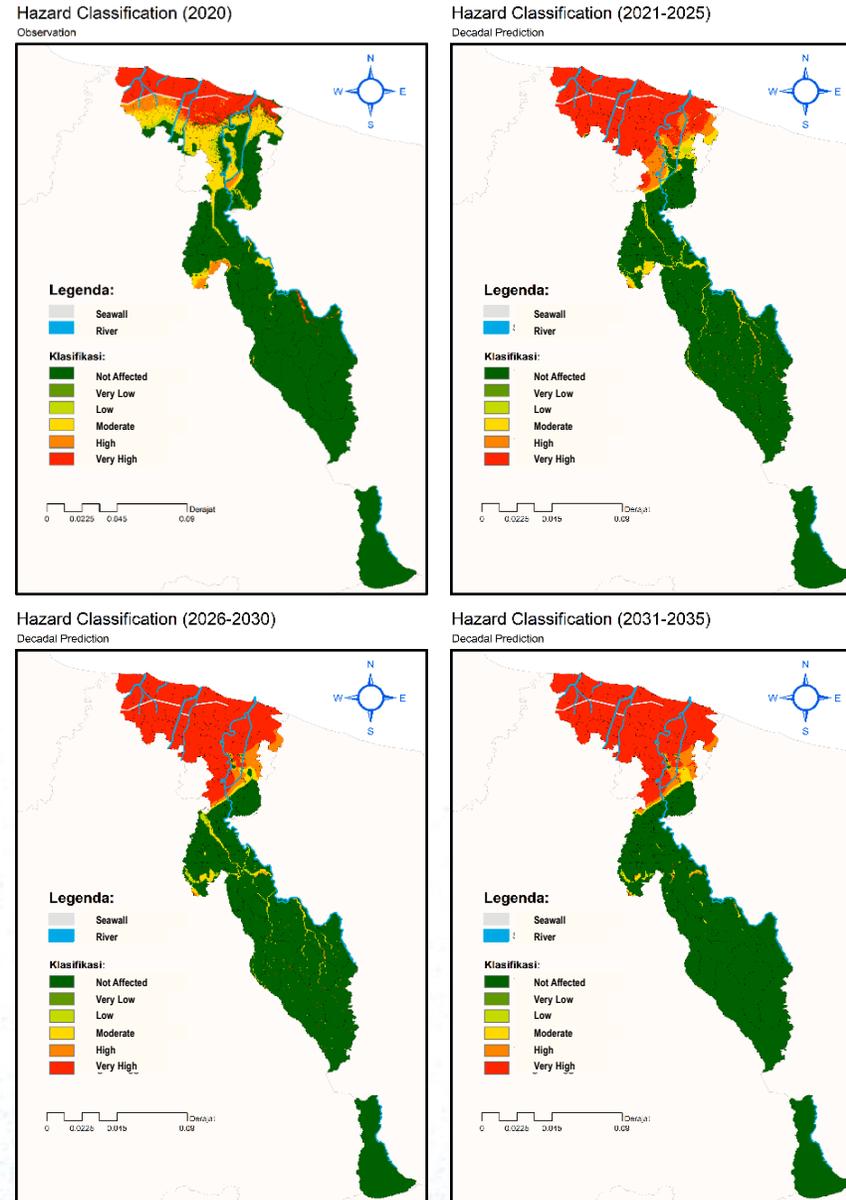
A. Observation Period

The hazard index in the observation period shows that the hazard level in most of the coastal areas, with east coast as the exception (Degayu and Krapyak), are categorized to be very high. The high category domination was found in the southern area of the seawall, including: Wonokerto Kulon, Tratebang, Wonokerto Kulon, Api-Api, Pecakaran; as well as some locations in middle area such as Pakisputih, Pejambon, and Kuripan Yosorejo. Other areas dominated by rain flood are facing moderate hazard index.

B. Projection Period (2021-2035)

The decadal prediction in every period shows hazard increase in the study location, particularly in the southern and middle areas. In 2021-2025 and 2026-2030, the hazard category will increase up to very high level in the southern parts of the seawall until Medono area. Similar increase was also found in the east coast, from moderate level to very high level category (for the majority). For the period of 2031-2035, the most significant change will take place in the southern area of Pekalongan City, which experiences increase of hazard category, from moderate or unaffected to high or moderate.

The development of hazard index with RCP4.5 scenario shows a not significantly different pattern from that of decadal prediction, although there is also tendency that the projection results will have higher hazard level as compared to that of the decadal simulation. The RCP 4.5 scenario was used to illustrate worse condition as compared to the decadal prediction.



Hazard Map from the Observation Period and Decadal Prediction (Author Team, 2020)

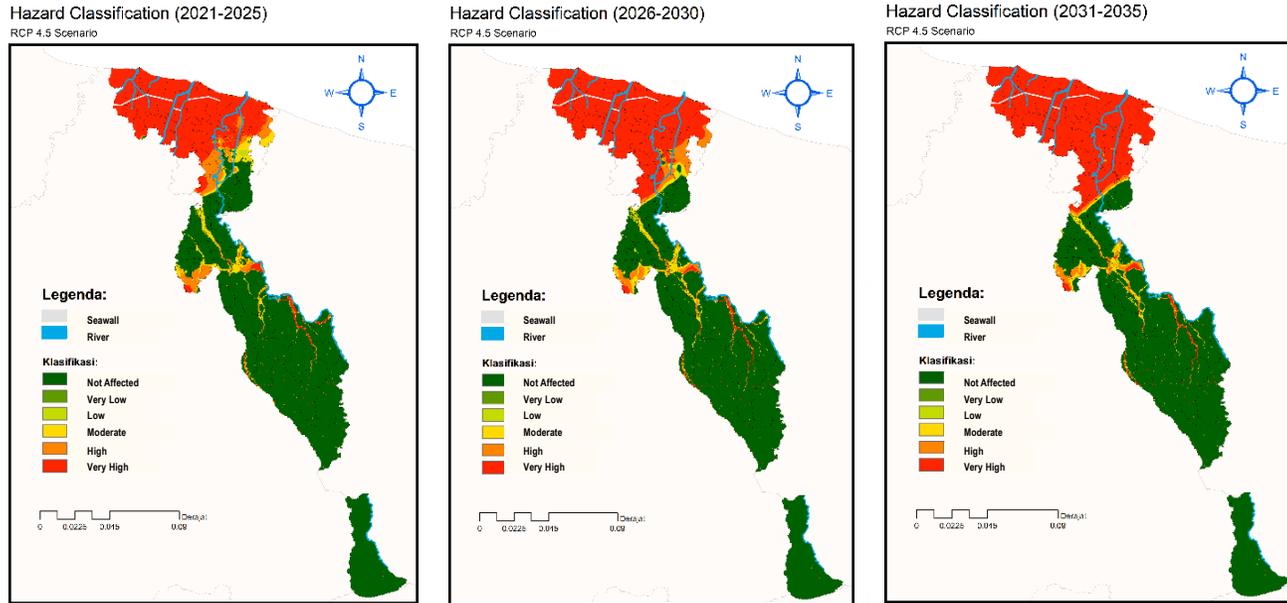
Similar to hazard level in decadal prediction, in general, the northern part of the study area experiences increasing hazard category from moderate/high to very high according to RCP 4.5 projection. The very notable difference was found in the middle section of the study area, which faces much higher hazard level compared to decadal prediction results.

Several locations in middle area such as Jalilembu, Pejambon, Pakisputih, and Kwayangan have moderate to very high hazard category. The high hazard level in this area is caused by the fact that its topography is passed by stormwater runoff.

With regard to the number of affected village, for Pekalongan Regency, both hazard projection schemes show that the number of villages having very high (VH) hazard level in the period of 2031-2035 will increase by two folds as compared to the observation condition (from 6 to 13-14 villages).

A more significant increase will take place in Pekalongan City, where during the period of 2031-2035, the number of *kelurahans* with VH hazard level will become 18-22 *kelurahans*, from initially 3 during the observation period. This increase will take place along with the decreasing number of *kelurahans* with very low (VL) and low (L) hazard level.

For the entire study area, the number of village/kelurahan with VH hazard index is estimated to increase from 10.7% during observation period to 25%, 32.1%, and 38.9% consecutively in 2021-2025, 2026-2030, and 2031-2035, according to the decadal prediction. Meanwhile, the RCP4.5 scenario projection suggested that the increase will reach 26.2%, 38.1%, and 42.9% consecutively in 2021-2025, 2026-2030, and 2031-2035.



Flood Hazard Index of RCP 4.5 Scenario Projection (Author Team, 2020)

Hazard Level	Observation	Decadal Prediction			Observation	Scenario (RCP 4.5)		
	2015-2019	2021-2025	2026-2030	2031-2035	2015-2019	2021-2025	2026-2030	2031-2035
Not Affected	17	5	12	21	17	4	3	4
Very Low	38	43	33	24	38	38	37	33
Low	12	3	4	1	12	6	5	4
Moderate	6	2	3	3	6	4	4	4
High	2	10	5	4	2	10	3	3
Very High	9	21	27	31	9	22	32	36

Number of Village/Kelurahan and Hazard Level in the Study Area (Author Team, 2020)



Bab 04.

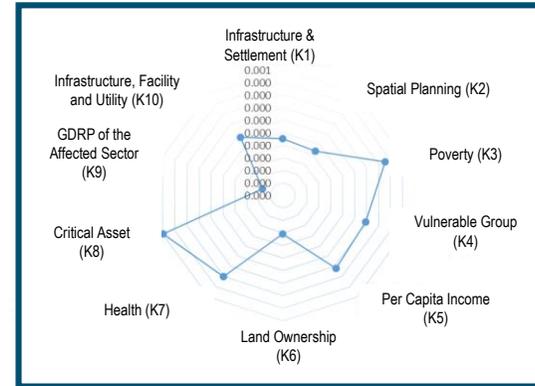
VULNERABILITY ANALYSIS

4.1 | Baseline Condition

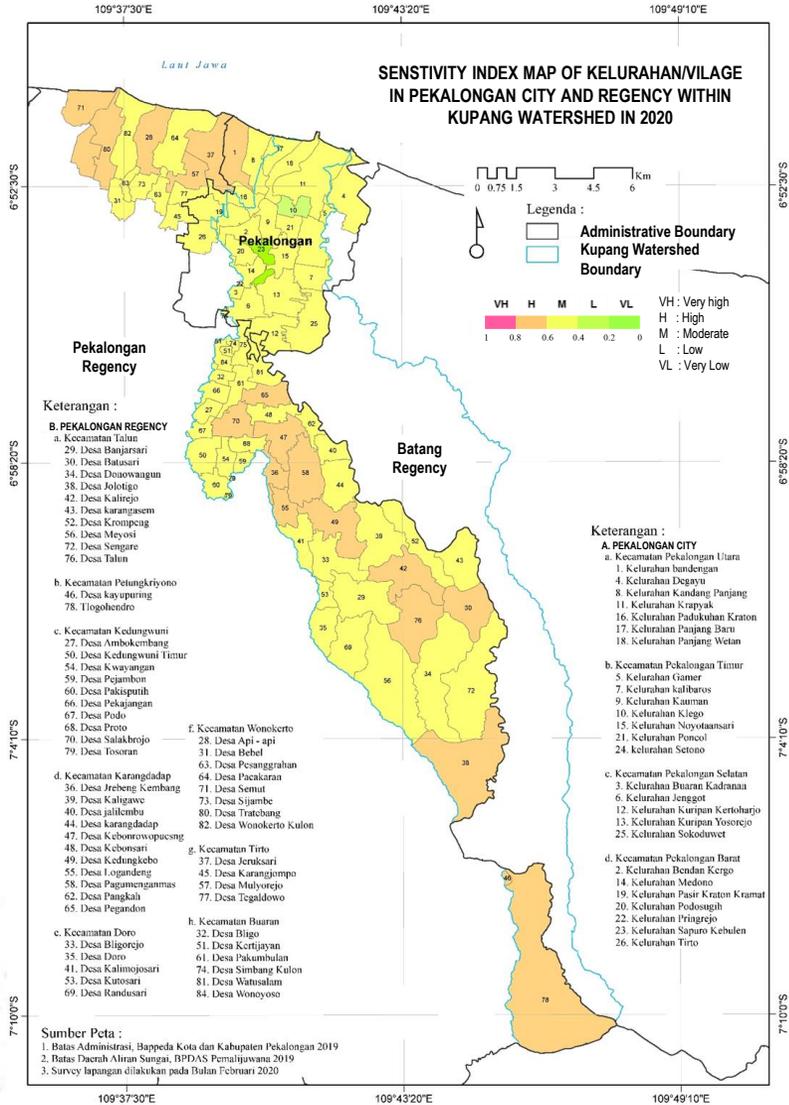
A. Sensitivity Analysis

The sensitivity level in the study location is generally situated at moderate-high, although some *kelurahans* show low (Klego) and very low (Sapuro Kebulen) levels. In coastal area, the analysis results show that coastal villages in Pekalongan Regency tend to have higher sensitivity level as compared to the coastal *kelurahans* in Pekalongan City (which are dominated by moderate sensitivity level, except for Kelurahan Bandengan).

With regard to the building component, the sensitivity level in the study location is dominated by critical asset component represented by the indicator of number of critical assets affected by the flood. Being a dominant component, it shows a number of critical assets in the study location that are potentially affected. The more critical assets that might potentially be affected are, the more burdens that the local government have to bear to mitigate the disaster risk in that particular *kelurahan/village*.



Another component playing high influence to the study location's sensitivity is the health component represented by the indicator of number of incidents of water-borne disease per district. This incident is tightly related to the frequency and intensity of flood event in an area. The significant influence from this component to sensitivity level in the study location shows that incidents of water-borne disease occur rather frequently, particularly in the flood-affected districts.



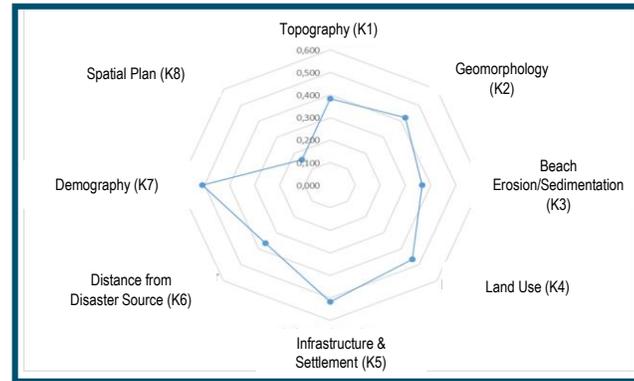
Map of Spatial Distribution of Sensitivity Index of 2020 (Author Team, 2020)

B. Exposure Analysis

The spatial distribution of exposure index shows that the study locations have varied exposure level from very low to very high, with higher level found in upstream and coastal areas.

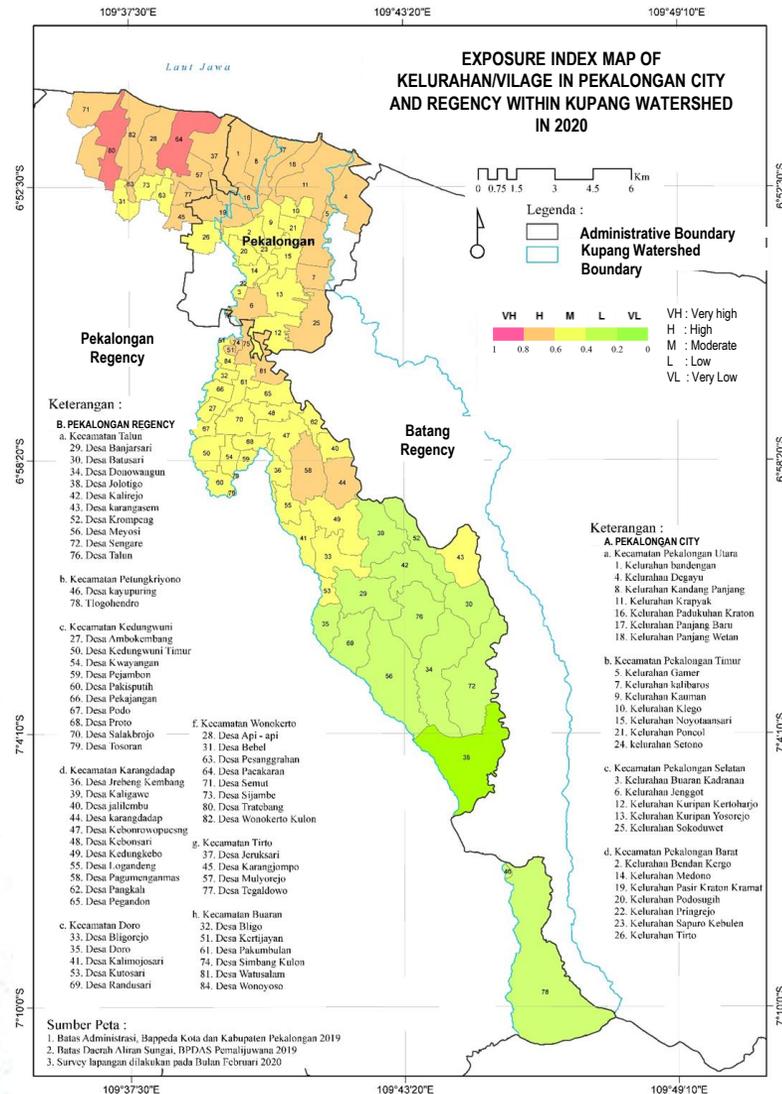
The high and very high exposure level dominate the downstream and coastal areas, particularly the coastal village/*kelurahan* (bordered by the sea); where there are **two villages with very high level of exposure, namely Pacakaran and Tratebang Villages**. The exposure dimension is strongly related to the potential of an area to be exposed to hazard potentials, so that it can be seen that coastal areas that have been exposed to tidal flood (and flood in downstream) and with relatively flat topography have higher exposure as compared to other areas. The high exposure level is very much influenced by population density and the highly developed land in the area.

The level of exposure of middle area is dominated by moderate level, although some villages also show high exposure level.



The emergence of high exposure level locations in middle area are generally caused by its locations that are situated close to water body, land use that is dominated by productive and settlement areas, land subsidence rate, as well as influence of topographic and geomorphological aspects. Meanwhile, upstream area is dominated by low level exposure.

Domination analysis shows that **demographic, infrastructure and settlement components are the most influential components to exposure level**. An aspect that ought to be considered is **the connectivity between demographic components with land use as well as infrastructure and settlement with topography**. The change of population density will influence change in land use, while topographic change will influence infrastructure and settlement. Both will change the potential impacts of a disaster incident.



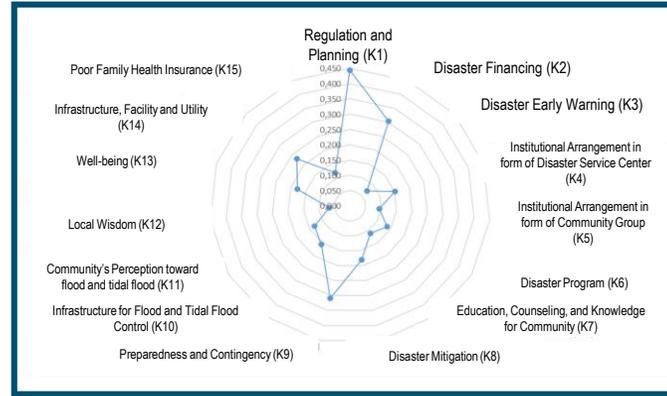
Map of Spatial Distribution of Exposure Index of 2020 (Author Team, 2020)

C. Adaptive Capacity Analysis

The adaptive capacity levels of the study location range from low to high, with regency area generally has lower level than that of city.

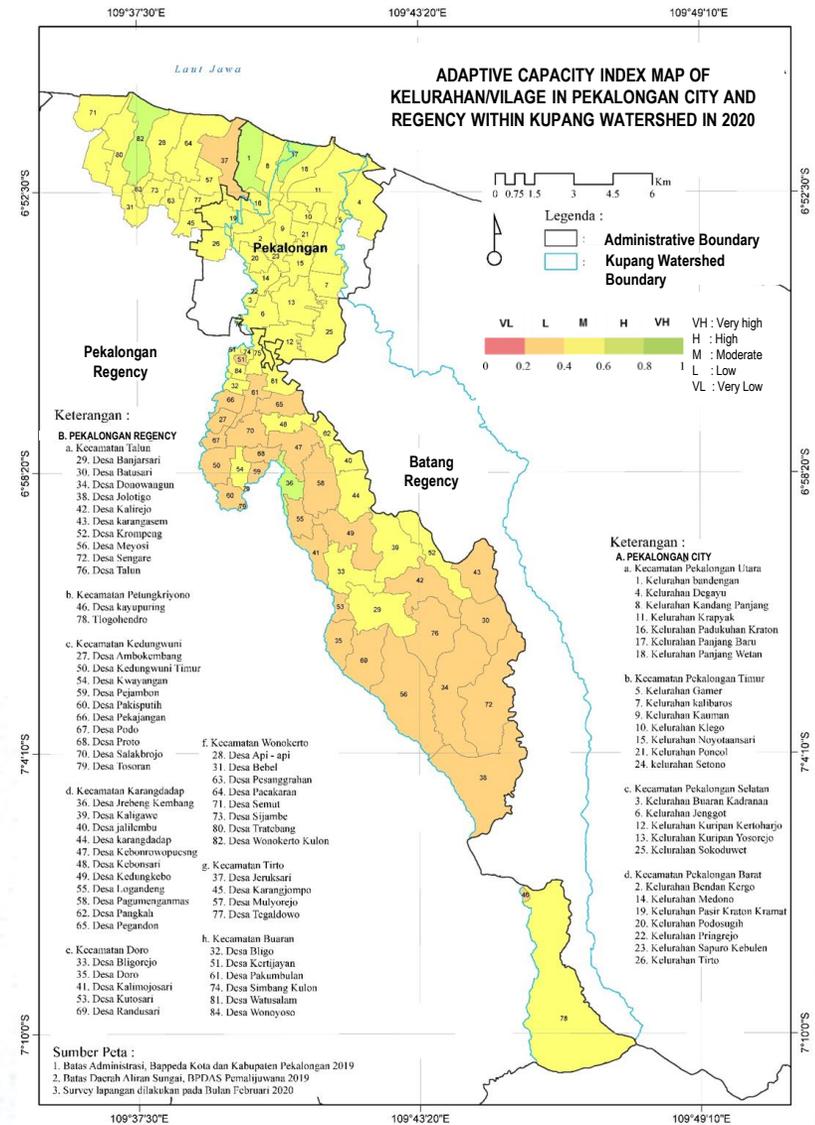
Moderate level adaptive capacity is currently dominating the coastal area, except Jeruksari Village (low) and Wonokerto Kulon Village, Kelurahan Bandengan, and Kelurahan Panjang Baru (high). Special attention is required to Jeruksari Village and Kelurahan Bandengan, which have rather different adaptive capacity, despite being located next to each other. This is because institutional-wise (regulation, financing, and early warning), Kelurahan Bandengan is at better level than Jeruksari Village.

For downstream area, the adaptive capacity is predominantly moderate. **The more inclined to the middle and upstream, the more the adaptive capacity of the study location decreases to the point where low level dominates**, except in Jrebeng Kembang Village (high). The condition is caused by the adaptive capacity building component, which is strictly related to the institutional framework of the local government to mitigate flood and community's "experience" in dealing with flood.



For middle and upstream areas, which currently rarely or have never experienced any flood, it is only natural if they are not being the main concern of the local government in flood mitigation. Likewise, the community's preparedness is hardly sufficient.

Looking at the main components determining adaptive capacity level in the study location, it can be seen that **the regulation and planning, disaster early warning, preparedness and contingency are the 3 dominant main components**. With regard to regulation, planning and early warning, generally the level is very low-low (except regulation in Pekalongan City that is already high), while the preparedness and contingency components are dominated by high-very high level.



Map of Spatial Distribution of Adaptive Capacity Index of 2020 (Author Team, 2020)

D. Vulnerability Analysis

The vulnerability level of the study area was developed in accordance with each area's level of sensitivity, exposure, and adaptive capacity. The lower the adaptive capacity and the higher the sensitivity and exposure are, the higher the area's vulnerability level will be.

In baseline condition, the analysis results show that the study location has moderate-very high vulnerability level. **The high vulnerability level dominates the study location (38% village/kelurahan),** followed by moderate level (28% village/kelurahan). However, when observed from vulnerability building dimension, it can be seen that the moderate level has higher portion (the most number of village/kelurahan) in the components of sensitivity, exposure, and adaptive capacity, particularly for sensitivity component. However, after being aggregated, the high vulnerability level turns out to have larger proportion.

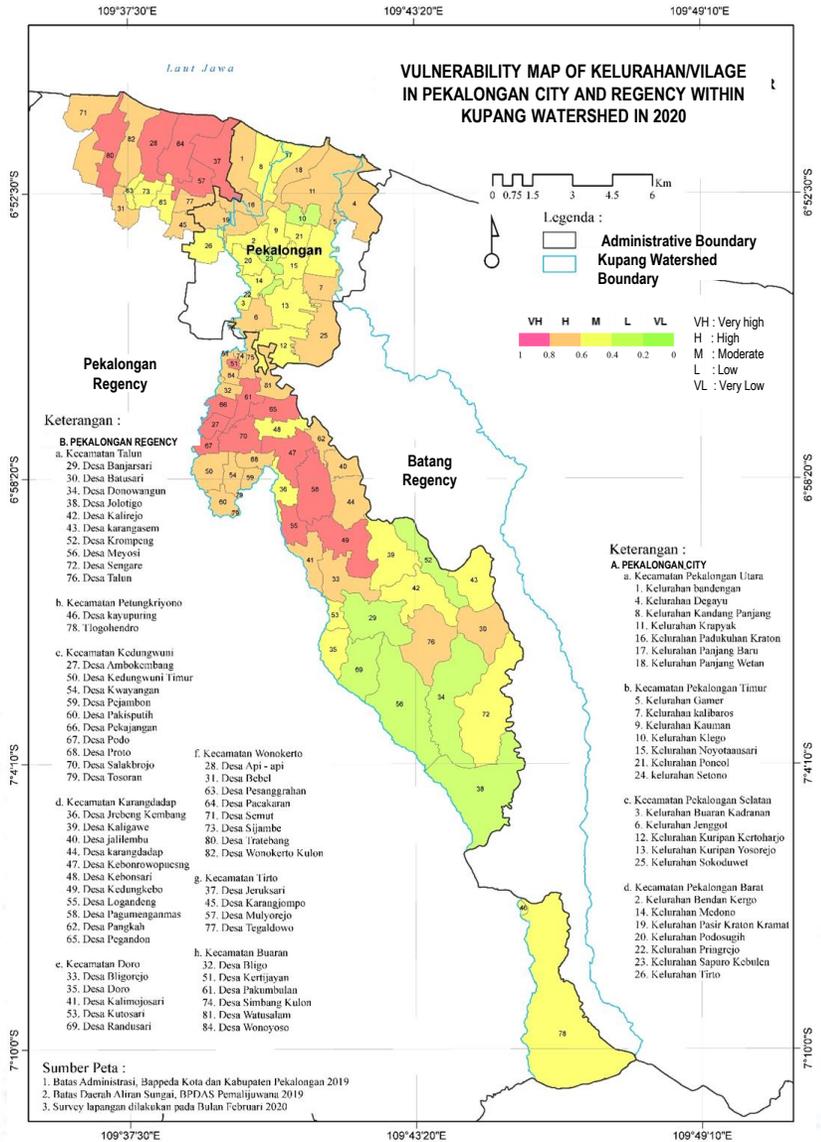
Very high vulnerability level was only found in 16 villages in Pekalongan Regency, which are spread across the coastal and middle areas. This shows that high vulnerability does not occur only in areas directly affected by the tidal flood.

For villages with **very high vulnerability level**, analysis shows that such a level **tends to be caused by their low adaptive capacity and high sensitivity.** Approximately 75% of the village/kelurahan with very high vulnerability have low adaptive capacity level, and 60% have high sensitivity level. Meanwhile, the high and very high exposure levels were found in 31% and 12.5% villages/kelurahans, consecutively.

The gap of adaptive capacity levels between Pekalongan Regency and Pekalongan City has led to different vulnerability levels between both areas.

Thus, to reduce the village/kelurahan's vulnerability in the study location, it is necessary to increase the quality of the main component that influences adaptive capacity and local area's sensitivity levels, namely the critical assets: health; regulator and planning; and disaster early warning.

Another matter that needs to be highlighted is the existence of villages with moderate and high vulnerability levels in the upstream area.



Map of Spatial Distribution of Vulnerability Index of 2020 (Author Team, 2020)

4.2 | Projection Elements

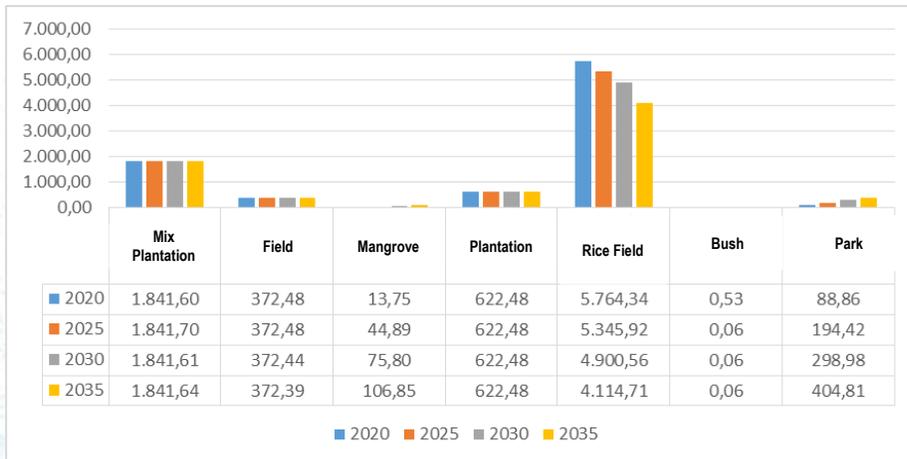
A. Sensitivity Projection

The components that were dynamically projected for sensitivity were spatial planning, poverty, vulnerable group, per capita income, and GRDP of the affected sector.



Spatial Planning

The premise of this component projection is that the dynamics of city development will suppress the development of green areas in the study location. The lower the size of green area is, the lower the water absorption capacity will be, which in turn will decrease the area's sensitivity. The projected changes in green area size in time series manner was carried out using the spatial dynamic model with *cellular automata*.



Projection of Green Area Size Changes (Author Team, 2020)

The modelling results in general indicate that there is no changes in size of the combined garden, field/moorland, and plantation. Meanwhile, **the decrease of land size might be identified in the ricefield/secondary crop field, which is caused by, among others, the developed area (settlement, industry, etc.).** The increase of land size can be found in mangrove and park, which reflects optimistic conservation measures by the local government.



Poverty Rate

Poverty rate will affect the population's ability to deal with flood risk. The projection of poverty number will be conducted by looking at the trend of poverty number development in historical time series manner, poverty alleviation targets set out in the document and local policies, as well as influence from the potential population growth. The projection results show that poverty rate in Pekalongan Regency and Pekalongan City will decrease to 3.81% and 3.1%, consecutively.



Vulnerable Group

Vulnerable groups (women, children, elderly, and person with disabilities) are community groups with relatively lower resilience and capacity to address flood issue as compared to those of other groups. The projection of vulnerable groups was conducted by using geometric statistical method by looking at historical growth trend. Projection shows that in the future, the number of vulnerable groups in both Pekalongan Regency and City will tend to increase, except that of children group in Pekalongan City, which will be relatively stable. The difference in growth trend will slightly influence the sensitivity level in both areas.



Per Capita Income

The per capita income projection was carried out by using basic data, i.e. district statistic data in number to indicate per capita income per village/*kelurahan* and village/*kelurahan* statistics in number from the past 5 years. The projection method used was ETS Method.

The projection results indicate that per capita income for Pekalongan City will have a positive trend, and reach IDR 70,147 by 2035. Positive trend was also found in Pekalongan Regency, yet with relatively flat slope. By 2035, the per capita income of Pekalongan Regency was estimated to reach IDR 49,422.



GRDP of the Affected Sector

Similar to per capita income, the GRDP projection of the affected sector was also carried out by using ETS method, using the historical per sector GRDP data taken out from the local government policy document. The affected sectors in this study comprise of agriculture, forestry, and fishery. From the projection results, it was found out that the affected sectors' GRDP in the Pekalongan Regency and City are, consecutively, IDR 2,767,409 and IDR 380,718.

B. Exposure Projection

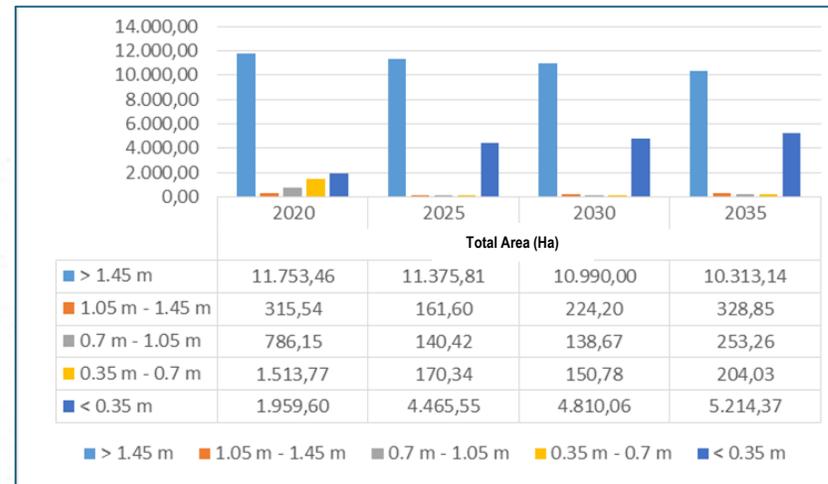
The components that are dynamically projected for exposure are topography, demography, and spatial planning.



Topography

The premise of component projection is that villages/*kelurahans* located in slight inclination (slope) and relatively low land surface will be more exposed to flood since the water flow in the area will tend to be slow or hampered, and the areas will potentially be inundated by the tidal flood. The projection of inclination and land surface height was conducted by using DTM data reconstruction, using land subsidence data processed from InSAR data. The data was taken from Sentinel-1 satellite for every projection period.

The projection results show that there will be changes of inclination at every level, with the highest size growth to be found in inclination of <2°; while the other inclination levels will experience decrease of size. With regard to land surface elevation, there is a significant size decrease of areas with land surface elevation of >1.45 m and 0.35-0.7m, with size changes reaching 1.300-1.400 Ha until year 2035. Meanwhile, for elevation <0.35 m, there will be substantially significant increase in size, with number of change reaching 3,300 Ha by 2035 as compared to that of 2020. This indicates that there are more areas that will be potentially affected by flood and tidal flood.



Projection of Size Change per Land Elevation Class in Study Location (Author Team, 2020)



Demography

The demographic projection was carried out by using geometric statistic method against the historical trend of population density per village/*kelurahan*. The projection shows that there will be a linear increase of population density both in Pekalongan City and Regency, yet the number of population density in both areas are significantly different. The population density in Pekalongan City by 2035 is estimated to be 13,667 people/km², while that of Pekalongan Regency will be 3,641 people/km². This discrepancy is caused by the fact that urban spatial pattern has denser characteristics as compared to that of rural. Furthermore, land availability in urban area is more limited, thus making the settlement density higher.



Spatial Planning

Projection in this component was carried out to identify the change of settlement size located in beach/river boundary. The projection was conducted by using spatial dynamic model. The modelling indicates that until 2035, there will be a steady increase of settlement size by 1,000 Ha in the study location. However, the increase will take place along with the increase of inundated and tidal flood affected areas. This indicates the potential expansion of settlement areas that will be inundated or affected by tidal flood. This should become a concern in area planning, as any growth of settlement prompted by population growth might be affected by land limitation that might be caused by inundation.

C. Adaptive Capacity Projection

The components that were dynamically projected for adaptive capacity are disaster programs, flood and tidal flood control infrastructure, and poor family health insurance.



Disaster Program

The projection process for disaster program component was based on Pekalongan City and Regency Governments' programs on disaster and conservation that were planned to be implemented during each projection period. The policy used as the reference of this process was the Spatial Plan of each area.



Infrastructure for Flood and Tidal Flood Control

Similar to disaster programs, the projection process for this component was conducted by studying the projection indications related to development/improvement of flood and tidal flood controlling infrastructure, such as dike, seawall, polder, retention pool, pump, etc. The policy used as the reference of this process was the Spatial Plan of each area.



Poor Family Health Insurance

Health insurance projection was carried out by using historical data of the proportion of poor community having KIS (Healthy Indonesia Card) and employing linear regression method, which mainly focused on the use of subsidized BPJS. The projection results show that there is a periodic declining trend in the proportion of community using Subsidized BPJS. This condition indicates that community's well-being will improve in the future.

4.3 | Vulnerability Projection (2021-2035)

Projection of vulnerability index and its dimension were obtained from the static and dynamic projection process against its building components.

A. Sensitivity Trend

Data processing results for the entire projection period shows that sensitivity level in the study location generally shows a declining trend, thus it can be said that the sensitivity of the study location is getting better. In baseline condition, the sensitivity level in the study location is generally ranges between moderate to high level. **By the end of projection period (year 2035), the sensitivity will be dominated by low and moderate levels,** with only 2 villages having high sensitivity level (in Pekalongan Regency).

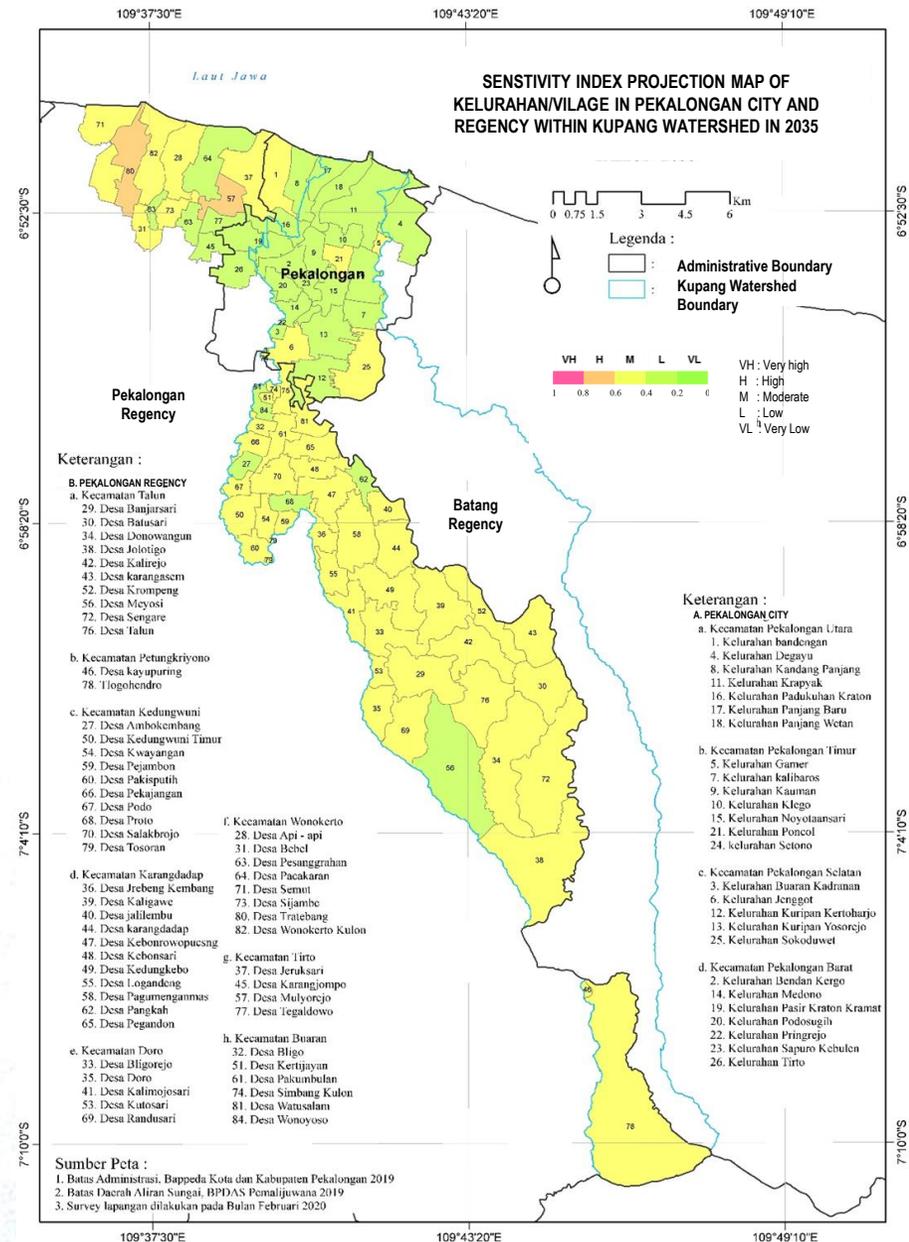
This change is influenced by the positive trend in poverty and per capita income components. By the end of the projection period, there will be no village/*kelurahan* categorized as high or very high levels in both components. In baseline condition, 54 village/*kelurahans* have such a range in poverty component, and which is similar to the 25 villages/*kelurahans* for per capita income.

However, it should be noted that the **two components have their limitations, i.e. potential of bias in areas with varied characteristics, as it is inclined toward generalization.**

Comparing between Pekalongan City and Pekalongan Regency, it can be seen that both in baseline condition and projection, Pekalongan City has lower sensitivity level compared to Pekalongan Regency.

The sensitivity level of Pekalongan City by the end of projection period will be dominated with low level, with only 5 *kelurahans* are at moderate level, namely: Kelurahan Bandengan, Gamer, Jenggot, Poncol and Sokoduwet. Both Kelurahan Jenggot and Sokoduwet do not experience any change in sensitivity level from that of the baseline condition.

For Pekalongan Regency, its sensitivity by the end of projection period will be dominated by moderate level, particularly in middle and upstream areas. In coastal area, there are two villages with high sensitivity level, namely Tratebang and Mulyorejo Villages, which do not experience any index change from the baseline condition. There is also 1 village with low sensitivity level in the regency's coastal area: the Pacakaran Village.



Map of Spatial Distribution of Sensitivity Index of 2035 (Author Team, 2020)

B. Exposure Trend

By the end of the projection period, the exposure level in the study location varies between low to very high. In general, there is an increasing trend for village/*kelurahan* exposure level in the study location, particularly in coastal area and area near to the river.

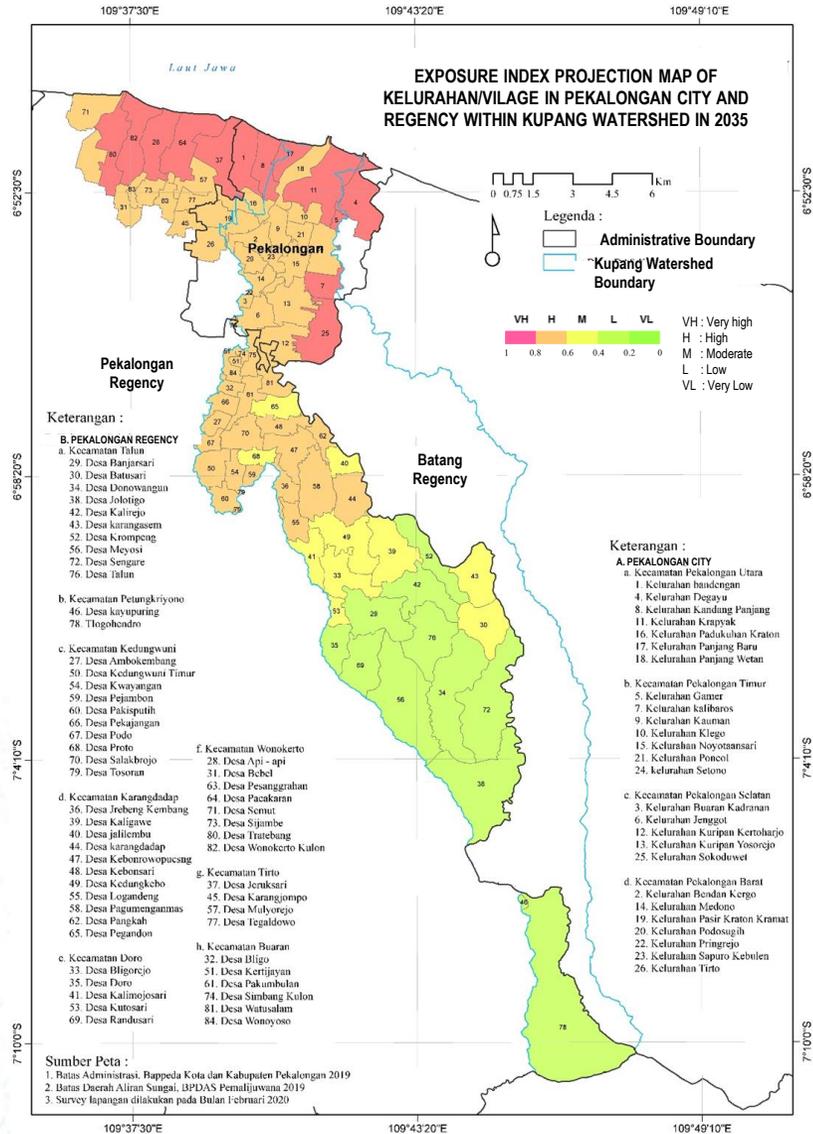
The increase of number of village/*kelurahan* having high-very high level in topographic and demographic components play major influence in the increase of exposure. The high level of topographic index results from the impact of the expansion of area with elevation of <0.35 m due to land subsidence, hence making the areas potentially exposed to flood wider. In addition, the change is also influenced by land use component which is projected to cause more villages switch to high-very high level.

The increased exposure seems to be relatively significant in downstream and coastal areas. The very high exposure level will dominate the coastal area, where out of 2 villages/*kelurahans* in the baseline condition, there will be 10 villages/*kelurahans* at very high exposure level by 2035.

Downstream area, which is initially dominated by moderate-high level, will become high-very high level by 2035, with very high level will occur in Kelurahan Kalibaros and Sokoduwet. In middle area, there will be changes in domination from moderate level in baseline to high level by the end of the projection period.

For upstream area, the change will be relatively insignificant. Low level will still dominate this area, with additional 1 village having high level (initially moderate during baseline: the Batusari Village) and 1 village having low level of exposure (from initially very low during baseline: Jolotigo Village).

The condition's change in downstream and coastal areas appear to be so visible from administrative perspective. Pekalongan City, which has moderate to high exposure level during baseline, by the end of the projection period will have high and very high levels of exposure. Pekalongan Regency will see the change in exposure level to reach the middle area. However, considering the appearance of villages with high exposure level at the upstream, there is possibility that the spatial distribution of high exposure level will move to upstream.



Map of Spatial Distribution of Exposure Index by 2035 (Author Team, 2020)

C. Adaptive Capacity Trend

The projection results in various periods show that the study location relatively does not experience significant changes on their **adaptive capacity level**. However, a **relatively positive trend can be found**, which is indicated from the adaptive capacity increase in several villages/ *kelurahans*.

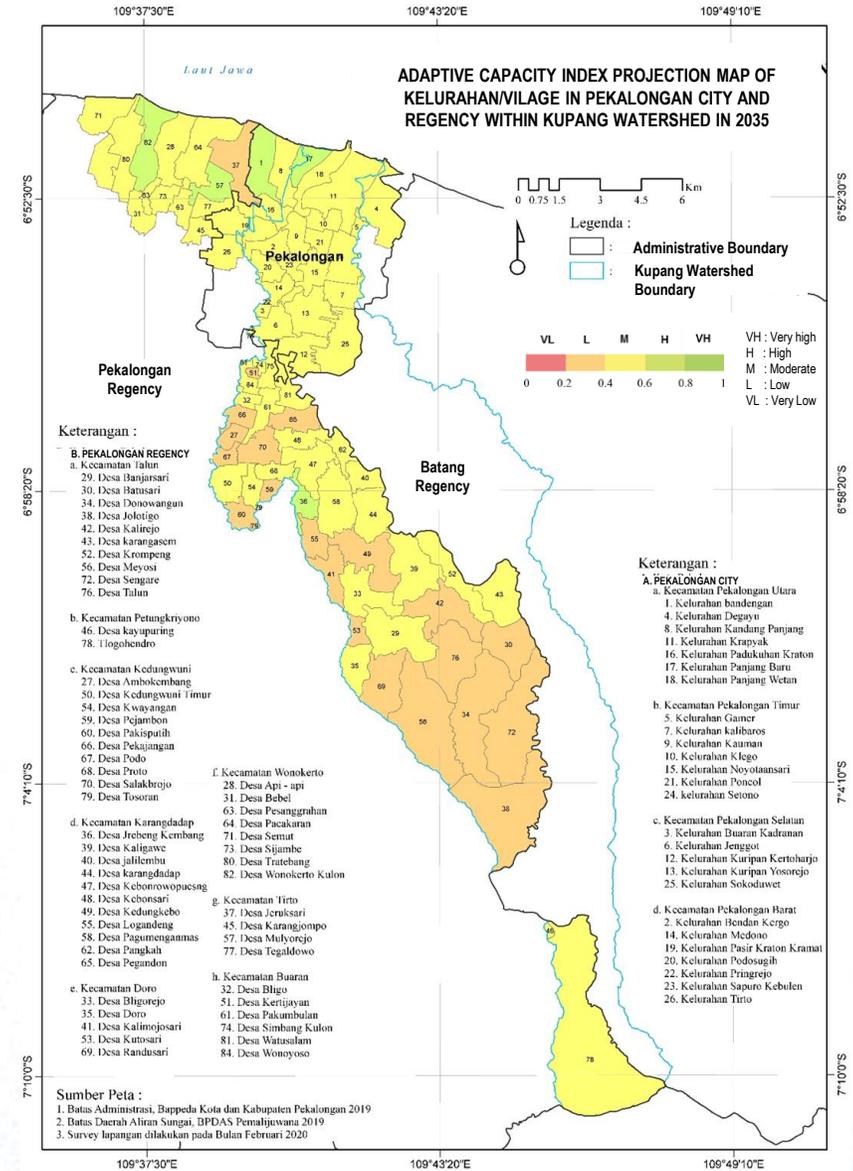
The changes tend to be caused by positive trend in the component of poor family health insurance program, which, during baseline, was dominated by low level (although few are of very high level), to moderate level in all villages/ *kelurahans*.

In general, similar to baseline, the study location is still dominated by moderate to low adaptive capacity, with increasing number of villages/ *kelurahans* having moderate adaptive capacity level. There are 7 villages/ *kelurahans* that have been recorded to switch from low to moderate level, namely: Villages of Pakumbulan, Kedungwuni Timur, Proto, Kebonrowopucung, Pagumenganmas, Doro and Karangasem. The seven villages are located in the middle area of the study location.

In downstream area, there is 1 village experiencing adaptive capacity level change from moderate to high, namely Mulyorejo Village.

From administrative perspective, Pekalongan City in general has higher adaptive capacity level as compared to that of Pekalongan Regency, where almost all *kelurahans* are categorized as having moderate adaptive capacity level, with 2 having high level, namely *Kelurahan* Bandengan and *Kelurahan* Panjang Baru.

Meanwhile, Pekalongan Regency tends to be at low-moderate level, with three villages having high level, namely: Villages of Jrebeng Kembang, Mulyorejo and Wonokerto Kulon. For **Jeruksari Village**, by the end of the projection period, the village's adaptive capacity level is projected to remain at low level. This needs to be highlighted, since the village is historically the one facing tidal flood most frequently.



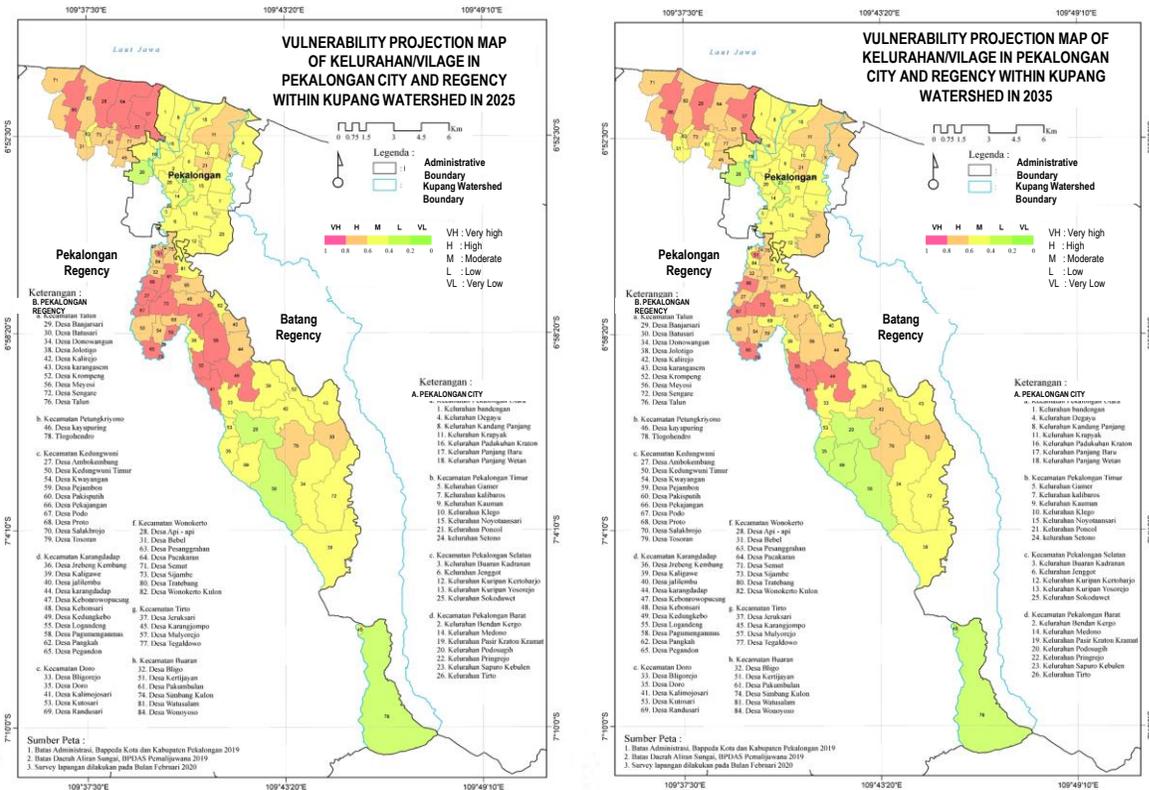
Map of Spatial Distribution of Adaptive Capacity Index of 2035 (Author Team, 2020)

D. Vulnerability Trend

The projection of vulnerability level in each period shows a rather different trend for each segment of the study location, yet in general, the changes that take place are not too significant.

In upstream area, there are several locations with increasing vulnerability level from low to moderate. The four villages are located within Talun District. However, in the same (upstream) area, there is also a village experiencing decrease of vulnerability level from moderate to low, namely Tlogohendro Village. The analysis results show that **the increasing vulnerability in upstream area tends to be caused by the increase of exposure in that area, with relatively minor changes in sensitivity and adaptive capacity.**

Vulnerability level for midstream area tends to decrease from the baseline year to the end of projection period. By 2035, there will be 4 villages experiencing changes of vulnerability level from very high in the baseline year to high, and 3 villages experiencing changes from high to moderate. However, there are also 3 villages found to experience increase of vulnerability from high to very high, namely the Villages of Pakisputih, Tosoran and Kalimojosari. **The changes in vulnerability in the middle area tend to be influenced by the declining sensitivity and increase of adaptive capacity;** however, some areas still experience increase of exposure, particularly in comparison between the baseline condition to projection condition by 2025.



Map of Spatial Distribution of Vulnerability Index of 2025 (left) and 2035 (right) (Author Team, 2020)

The downstream and coastal areas also experience a rather declining trend. The Villages of Pecakaran and Mulyorejo experience changes from very high vulnerability level during baseline condition to high by the end of projection period. The decline of vulnerability level is also experienced by the Kelurahan of Bandengan, Panjang Wetan, and Tirto. However, there is also an increase of vulnerability in this area in Kelurahan Poncol. **The decreasing vulnerability level in the area tends to be influenced by the decrease in sensitivity level and increase of adaptive capacity.** The exposure level in several locations in the area is actually also increasing, yet the influence seems to be relatively minor as compared to the sensitivity and adaptive capacity.



Bab 05. RISK ANALYSIS

The discussion on risk level will be separated between coastal and non-coastal areas. For this analysis, coastal area in the study location consists of 22 villages/*kelurahans* (13 villages in Pekalongan Regency and 9 *kelurahans* in Pekalongan City) as presented on the side image.

5.1 | Baseline Condition

A. Pekalongan Flood Context

The analysis results in the previous step show that the increase of sea level height is not the only contributor to the inundation increase in Pekalongan coastal area. The high rate of land subsidence also significantly contributes to the more rapid increase of permanently and farthest inundated areas in the coastal area. The condition is exacerbated by recurring current and tide of sea water and extreme rainfall. The analysis result and climate modelling in this study show that historically, there has been changes in climate variability, and this change will keep happening in the future, including extreme rainfall and its frequency of occurrence.

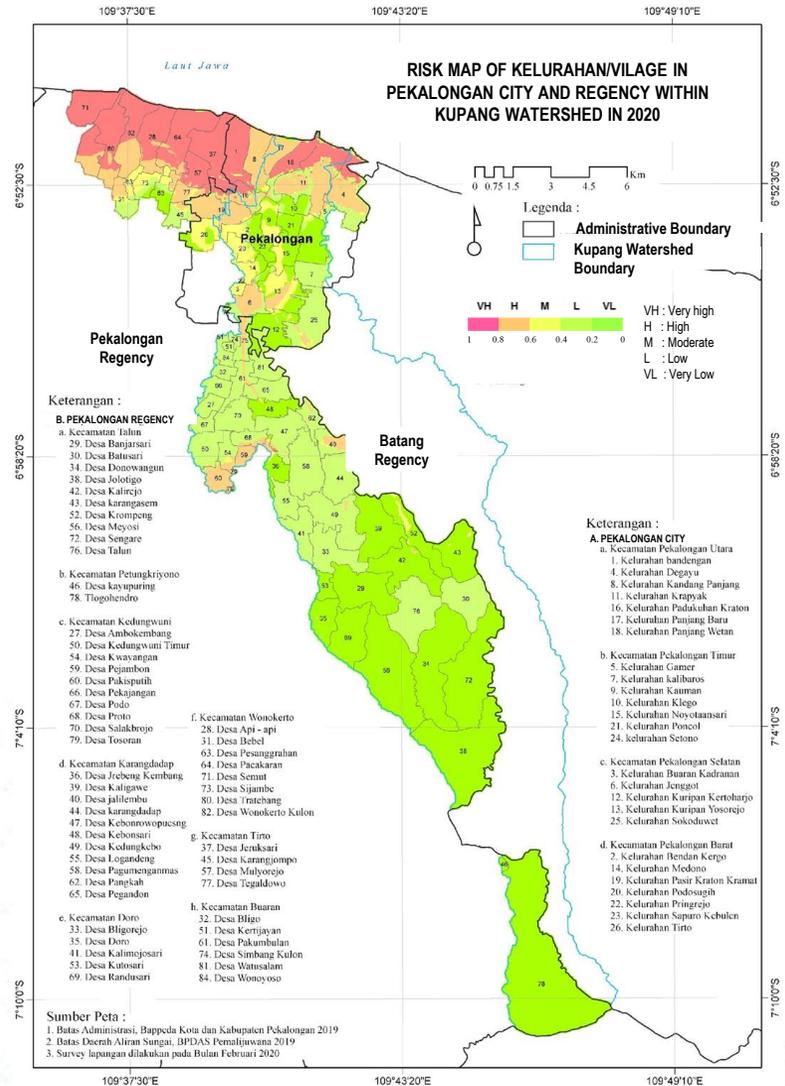
As for extreme rain, BNPB's historical data show that the flood hazard due to extreme rain does not only affect the coastal area, yet also the middle and upstream areas, particularly along the river flow, as well as other areas with lower elevation or slope.

Vulnerability analysis also indicates that the level of exposure, sensitivity, and adaptive capacity in the study location can also influence the flood risk.

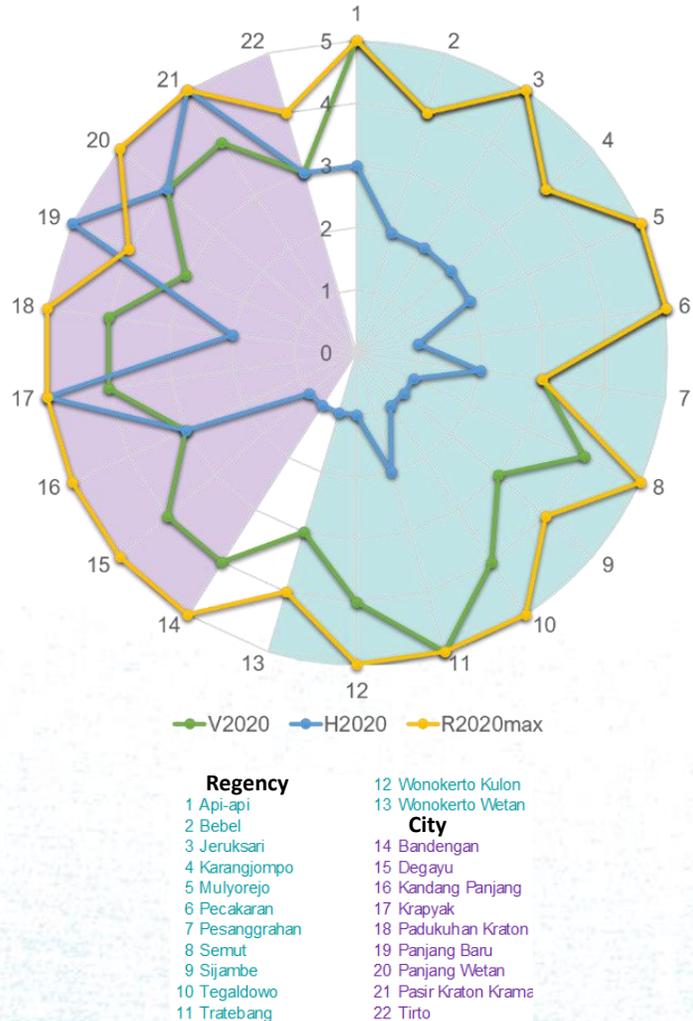
B. Baseline Risk in Coastal Area

The increasing hazard level in the coastal area will increase the risk in that area, particularly areas with high vulnerability level.

Comparison of hazard, vulnerability, and risk dimensions of all coastal villages/*kelurahans* in the study location show that in general, the villages/*kelurahans* have high and very high risk level, except for Pesanggrahan Village. This is because the village has very low hazard level and moderate vulnerability level. Other villages such as Bebel and Karangjampo also have very low hazard level, yet very high risk level due to its high vulnerability level.



Map of Spatial Distribution of Baseline Risk Index (Author Team, 2020)



Visualization of Vulnerability Index (V2020) and Hazard (H2020) that Compose Flood Risk (R2020max) in the Coastal Area (Author Team, 2020)

The vulnerability level was found to be in line with exposure, sensitivity, and adaptive capacity of the area, which is also at moderate-high level. Similar to the condition of Pekalongan Regency, most of *kelurahans* in Pekalongan City show moderate adaptive capacity level.

Deeper analysis was conducted on vulnerability level of coastal area to see the influence of each vulnerability component to its flood risk level, as well as to identify non-mitigational measures can be carried out to reduce the risk.

The high flood risk in the coastal area of Pekalongan Regency seems to not only caused by the high level of exposure, but also by its moderate-high sensitivity level; with adaptive capacity level in general situated under or equal to its exposure or sensitivity level, except for the Wonokerto Kulon Village.

Villages with very high vulnerability level such as the Villages of Api-api, Jeruksari, and Tratebang, were identified to have high exposure and sensitivity level, with low-moderate adaptive capacity. Thus, ideally, the adaptive capacity in those villages must be built to reduce the risk level.

For Pekalongan City, the high flood risk in the coastal area is also influenced by the level of area's vulnerability that ranges between moderate-high. The *Kelurahans* of Kandang Panjang, Panjang Baru, and Tirta, have moderate vulnerability level, while another *kelurahan* has high vulnerability level.

The fact that there is no village in Pekalongan City and Regency coastal area that show low and very low vulnerability level indicates further attention is needed. Well-planned adaptation measures are highly needed to increase the community's adaptive capacity, especially in dealing with the increasing flood hazard.

In addition, the potential of permanent inundation occurrence in the coastal area need more comprehensive adaptation options, which do not only focus on increasing the adaptive capacity, but also in formulating and implementing policies associated with supports to economic activities, infrastructure development, etc.

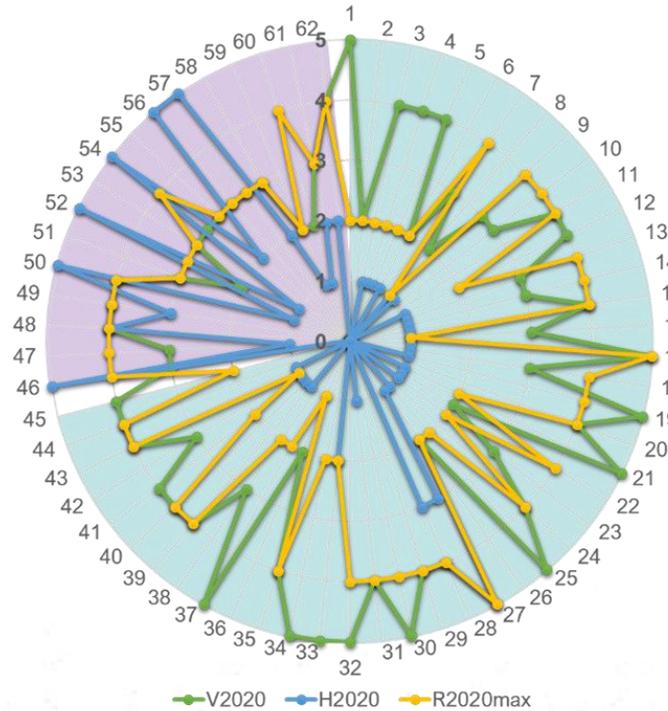
C.

Baseline Risk Level in Non-Coastal Area

The non-coastal areas referred to herein encompasses middle, upstream and downstream areas of Kupang Watershed, which are mostly dominated by Pekalongan Regency area.

The vulnerability level of non-coastal villages in Pekalongan Regency is in general at high level, although some villages were found to be at very high vulnerability level, such as Ambokembang, Kebonrowopucang, Kedungkebo, Kertijayan, Logandeng, Pagumenganmas, Pakumbulan, Pegandon, Pekajangan, Podo and Salakbrojo. The condition is caused by the sensitivity and exposure levels that are generally at moderate level and the averagely low adaptive capacity.

The averagely high vulnerability level then causes the non-coastal villages in Pekalongan Regency in general to have high risk. However, risk calculation also shows that some villages with high-very high vulnerability level have low risk level, such as the Villages of Batusari, Bligo, Talun, Wonoyoso, Ambokembang, Kertijayan, and Pekajangan. The low risk level of these villages is due to the very low flood hazard level in the area.



- | | |
|---------------------|-----------------------|
| Regency | |
| 1 Ambokembang | 32 Pegandon |
| 2 Banjarsari | 33 Pekajangan |
| 3 Batusari | 34 Podo |
| 4 Bligo | 35 Proto |
| 5 Bligorejo | 36 Randusari |
| 6 Donowangun | 37 Salakbrojo |
| 7 Doro | 38 Sengare |
| 8 Jolotigo | 39 Simbang Kulon |
| 9 Jrebeng Kembang | 40 Simbang Wetan |
| 10 Kaligawe | 41 Talun |
| 11 Kalilembu | 42 Tlogohendro |
| 12 Kaliwojoso | 43 Tosoran |
| 13 Kalirejo | 44 Watu salam |
| 14 Karangasem | 45 Wonoyoso |
| 15 Karangdadap | |
| 16 Kayupuring | City |
| 17 Kebonrowopucang | 46 Bendan Kergon |
| 18 Kebonsari | 47 Buaran Kadranan |
| 19 Kedungkebo | 48 Gamer |
| 20 Kedungwuni Timur | 49 Jenggot |
| 21 Kertijayan | 50 Kalibaras |
| 22 Kropeng | 51 Kauman |
| 23 Kutosari | 52 Klego |
| 24 Kwayangan | 53 Kuripan Kertoharjo |
| 25 Logandeng | 54 Kuripan Yosorejo |
| 26 Mesoyi | 55 Medono |
| 27 Pagumenganmas | 56 Noyontaansari |
| 28 Pajomblangan | 57 Podosugih |
| 29 Pakisputih | 58 Poncol |
| 30 Pakumbulan | 59 Pringrejo |
| 31 Pangkah | 60 Sapuro Kebulan |
| | 61 Setono |
| | 62 Sokoduwet |

Visualization of Vulnerability Index (V2020) and Hazard (H2020) that Compose Flood Risk (R2020max) in the Non-Coastal Area (Author Team, 2020)

The averagely high risk level was also found in non-coastal *kelurahans* in Pekalongan City, although some *kelurahans* also have low and moderate risk levels. The risk level is caused by the combination of relatively high flood hazard in the area and the relatively moderate vulnerability level. The moderate vulnerability level is composed of the relatively moderate sensitivity, exposure, and adaptive capacity of the area.

However, it is also possible to find *kelurahan* with low and very low levels of vulnerability, where this condition tends to be influenced by the sensitivity level of the *kelurahan* which is in the low-very low range. On the other hand, there are also *kelurahan* with high level of vulnerability, namely Gamer, Jenggot and Kalibaras.

Kelurahan Pringrejo is the only *kelurahan* with low risk level. Such a low risk was contributed by its low vulnerability level, although it has moderate level of flood hazard.

With regard to flood hazard, the non-coastal areas in Pekalongan City has higher flood hazard level as compared to the non-coastal areas of Pekalongan Regency. This is due to the fact that some areas face risks of tidal flood and flood caused by extreme rainfall.

What requires more attention regarding baseline condition of the non-coastal area is the fact that there are areas with low risk level yet high vulnerability level. Considering the relatively low adaptive capacity in the area, capacity building measures are necessary to strengthen the community's capacity in facing various potential hazards (other than flood).

Special attention is also required for areas with low risk level, although they might have moderate hazard level, such as *Kelurahan* Pringrejo. During flood risk mitigation, particularly when it comes to hazard mitigation, the *kelurahan* needs to be prioritized.

5.2 | Risk Projection (2021-2035)

Proper understanding on the historical condition related to flood hazard and information associated with its prediction and projection in the future is important in the risk analysis process. This baseline and projection information will help formulating the appropriate adaptation and mitigation strategies in the future.

Following the risk analysis approach used for the baseline condition in the previous part, the discussion on the risk projection analysis results was also conducted by using an analysis approach that differentiated between coastal and non-coastal areas.

A. Coastal Area Risk Level Projection

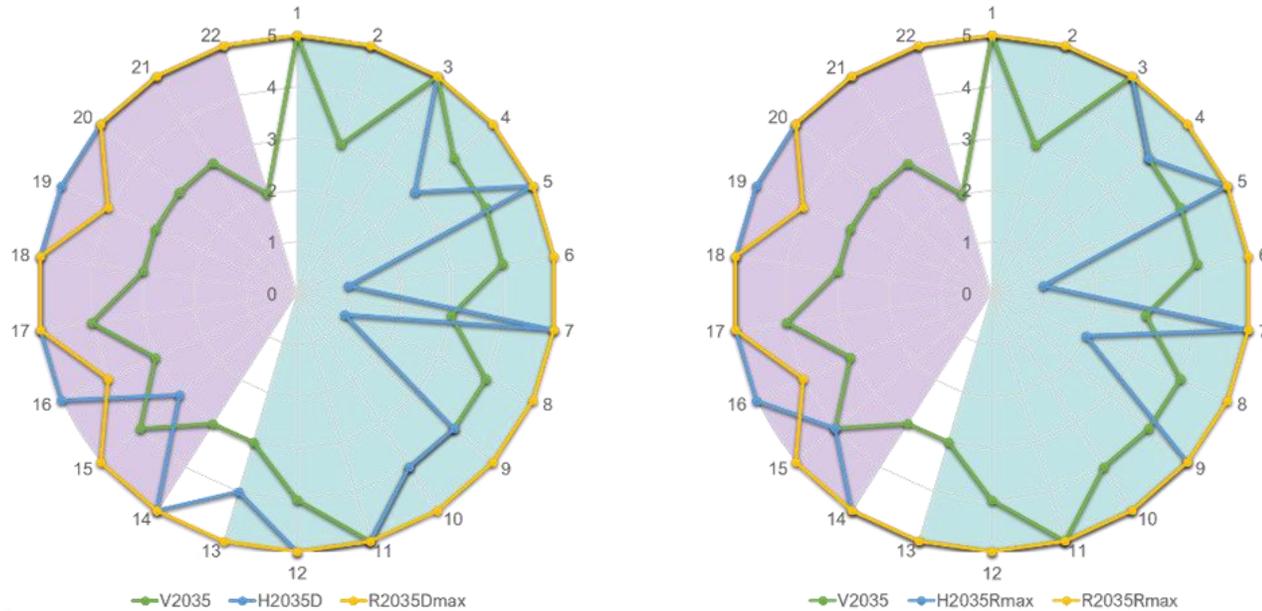
During baseline period, majority of villages/*kelurahans* in the coastal area have been in high and very high risk level, except the Pesanggrahan Village (moderate). The changes in hazard and vulnerability level in the future will certainly affect the risk level in the future.

The risk projection results, both produced by decadal prediction analysis and the RCP 4.5 scenario projection, almost entirely and consistently **show an increase of risk level in various projection periods, particularly from high to very high risk level,** although some vulnerability decrease also occurs in various areas.

The increasing risk is particularly caused by the tendency of increasing hazard to very high level that takes place in most of the villages/*kelurahans* in the coastal area, such as *Kelurahan* Bandengan, Degayu, Kandang Panjang, Krpyak, Padukuhan Kraton, Panjang Wetan and Pasir Kraton Kramat; as well as Villages of Api-api, Jeruksari, Mulyorejo, Pecakaran, Semut, Tegaldowo, Tratebang, and Wonokerto Kulon. Meanwhile, *Kelurahan* Kandang Panjang oppositely experiences decrease from very high to high level.

The combination of sea level rise rate (± 0.81 cm/year) and land subsidence rate (which reaches 34.5 cm/year) are the main contributing factors to the increasing hazard level in the future. The condition is exacerbated with changes of wet extreme index.

Furthermore, the inundation projection shows that there is potential increase of inundation size in coastal area, which will definitely contribute to the increasing flood risk. The changes of risk level to very high in almost all villages/*kelurahans* in coastal area, and the potential increase of inundation area size show the importance of selecting and strengthening the adaptation strategies.



Visualization of Vulnerability Level (V2035) and Hazard (H2035) that Compose Flood Risk (R2035max) in Coastal Area by 2035 with Decadal Prediction (left) and RCP 4.5 Projection (right) (Author Team, 2020)

The area should be considered as the main focus in disaster risk reduction and climate change adaptation programs. The increase of flood risk and size can harm people’s lives, due to the increasing number of exposed population, loss of productive and settlement areas, disrupted economic activities, as well as disrupted infrastructure service in the coastal area.

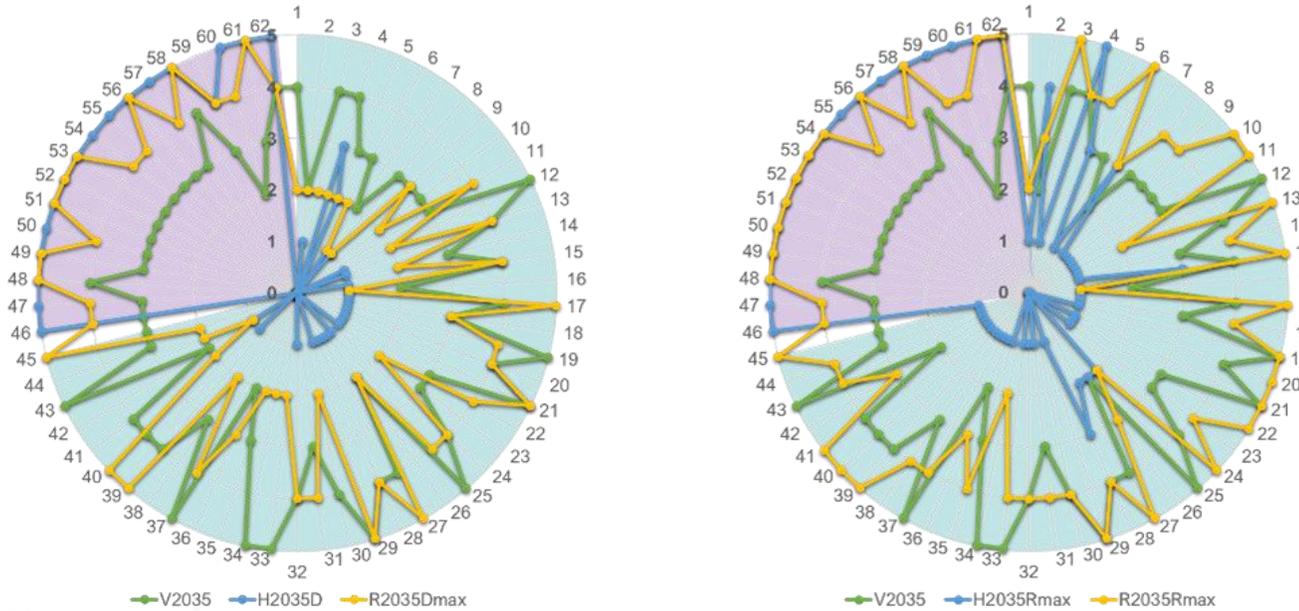
B. Non-coastal Area Risk Level Projection

The risk level projection for non-coastal area shows rather varying results with different dominant factors for both administrative areas. For Pekalongan Regency, the vulnerability level factor tends to be more dominant in influencing the risk level; while for Pekalongan Regency, the risk level is more influenced by the hazard level.

In general, the non-coastal areas of Pekalongan City are projected to have high risk level. The condition is caused by the predominantly moderate vulnerability level and very high hazard level.

Meanwhile, the vulnerability level of non-coastal areas of Pekalongan Regency is mostly at high-very high level, with average flood hazard level at not-affected-very low; thus several villages with high-very high risk level can be identified. However, several villages with low and very low risk levels can also be found.

The variation of risk level in a village/kecamatan due to the use of grid analysis unit in the risk analysis process is clearly visible for non-coastal areas as compared to coastal ones, particularly those situated near to the river. As an example, in the Villages of Pagumenganmas and Kalilembu, the high-very high risk level only occurs at grid area that has high-very high hazard level, while other areas have low risk.



Visualization of Vulnerability Level (V2035) and Hazard (H2035) that Compose Flood Risk (R2035max) in Non-Coastal Area by 2035 with Decadal Prediction (left) and RCP 4.5 Projection (right) (Author Team, 2020)

As for RCP 4.5 scenario, the high and very high risk levels will be found in 25 and 49 villages/*kelurahans* consecutively by 2035.

Looking at the administrative area, in **Pekalongan City**, the number of *kelurahans* that will experience higher risk level increase consistently, and by the end of the projection year, the entire *kelurahans* in the study location will have high-very high risk level both in decadal prediction scenario as well as RCP 4.5 projection; while in baseline year, the percentage of *kelurahan* with such a risk level is $\pm 65\%$.

For Pekalongan Regency, obvious difference was found between the projection results from decadal prediction and RCP4.5 projection. In baseline year, 36 out of 58 villages have high-very high risk level. By the end of the projection period, the number shifted to 32 villages and 48 villages for decadal prediction and RCP 4.5 projection, respectively. The decadal prediction shows a decrease in number of villages with high-very high risk level, while RCP 4.5 shows an increase. In decadal prediction, increase is more obviously occurring at moderate risk level. The difference in changes of risk level in decadal and RCP 4.5 predictions **show that the change of rainfall as the factor shaping hazard level influences the risk level in Pekalongan Regency.**

C. Risk Level Projection in the Study Location

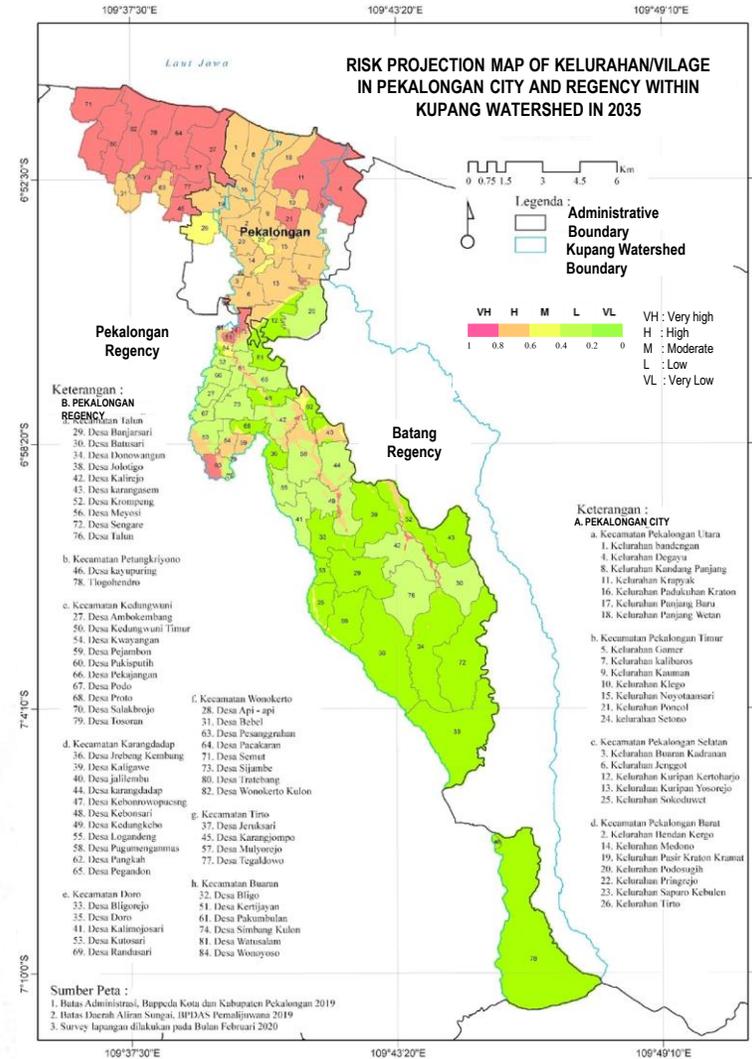
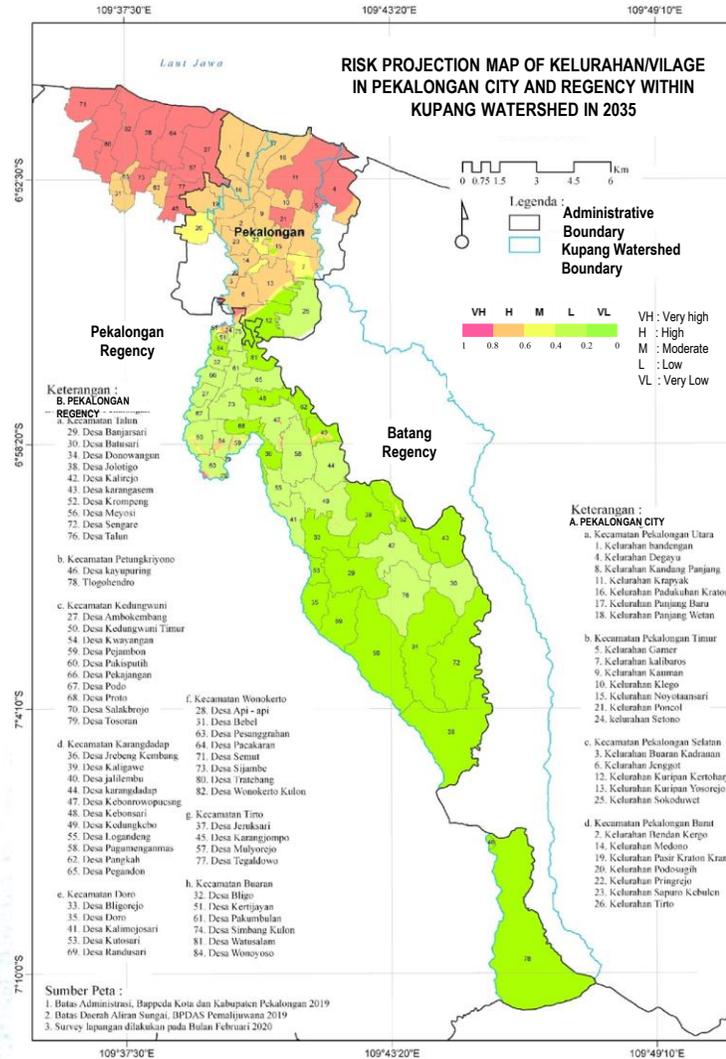
The analysis results show that in baseline year, in total, the study location is composed of 36 and 17 villages/*kelurahans* that have high risk and very high risk levels, consecutively. The number of villages/*kelurahans* with both risk levels will keep increasing up to 23 and 35 villages/*kelurahans*, consecutively, to high and very high levels by 2035 according to the decadal prediction.

Upon comparing the coastal and non-coastal areas in Pekalongan City and Regency, an obvious difference occurs regarding the characteristics of flood vulnerability, hazard, and risk levels between the compared areas. The differences in characteristics of vulnerability and hazard are obvious between city and regency, particularly in the non-coastal areas.

The distribution of risk level and its shaping factors indicate the importance of observing various building factors of vulnerability level and factors influencing the hazard level, so as to take the appropriate adaptation strategy for flood risk reduction in the future.

The difference of characteristics of vulnerability level and hazard level can be used to determine the most suitable adaptation option, either one that will focus on decrease of exposure and sensitivity level, or one that will focus on adaptive capacity, although basically both matters shall be carried out simultaneously.

In addition, the spatial distribution using the grid analysis unit can also help in directing to the right locus area to implement the formulated programs and activities.



Spatial Distribution of Risk Level in Risk Area by 2035 with Decadal Prediction (left) and RCP 4.5 Projection (right) (Author Team, 2020)

5.3 | Interlinkage between Land Use Change and Inundation

The analysis was carried out to look at the spatial impacts of the change in inundation size (both permanent and farthest) to land use in the study location, so that the policies and programs formulated for the area can be highly effective and efficient.

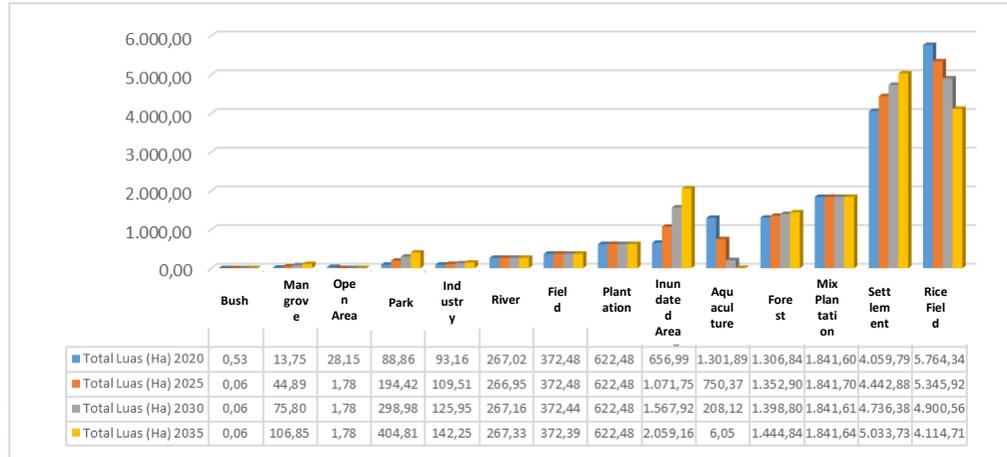
Land use classification utilized in the projection is the same with that of the baseline condition. One of the classifications used is the tidal flood/inundated land. This refers to the existing condition where there are areas in the study location that are permanently inundated. The land use locus of 'tidal flood/inundated land' of this land use projection is different from the 'permanent inundation' and farthest inundation' generated from hazard analysis process.

In this study, a premise was made, that the overlay areas between land use of 'tidal flood/inundated land' with 'permanent inundation' are areas with the highest probability to be permanently inundated in the future, since two different analysis processes show an identical result.

The overlay between the permanent inundation and farthest inundation within the land use other than tidal flood/inundated land will indicate the classification of potentially-affected land use.

A. Trend in Land Use Change

The projection indicates that by the end of the projection period, land use in the study location is still dominated by settlement and ricefield, in addition to forest. This shows that agricultural activity will still run as one of the main community's income sources. Looking at the change trend, significant change in land size was also found in the classification of settlement, ricefield, fish pond, and tidal flood/inundated land.

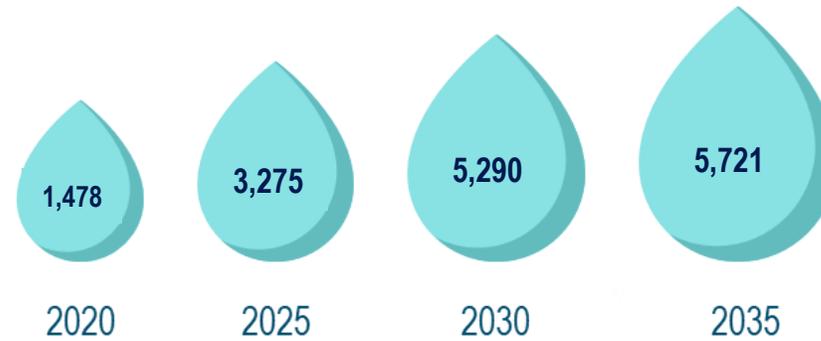


Change of Land Use in the Study Location for 2020-2035 (Author Team, 2020)

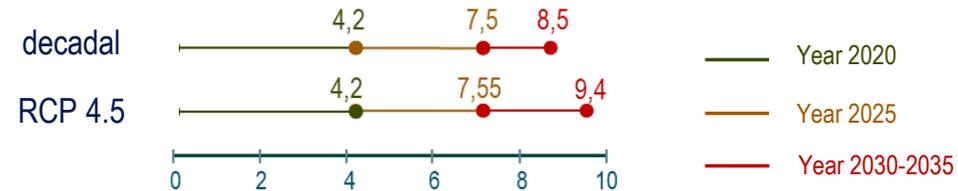
There is an increasing trend for the settlement size (± 1.000 Ha) and tidal flood/inundated land (± 1.400 Ha), while for ricefield and fish pond, there is a declining trend involving change of land size of approximately 1,600 Ha and 1,300 Ha, consecutively. Looking at this figure of change, it can be assumed that the expansion of tidal flood/inundated land and settlement areas takes place by changing the form of ricefield and fish pond.

Further analysis was conducted by looking into land use change in the coastal and non-coastal area segments to show the trade-off of the land use. For coastal area, it is obvious that the increase of **tidal flood/inundated land occurs in line with the decrease of fish pond size**; while settlement's size in the area tends to slightly increase. This shows that it is fish ponds that are commonly converted into inundated land.

For non-coastal area, the most significant size increase occurs in the settlement land use. Meanwhile, the most significant size decrease occurs in ricefield. Thus, it can be concluded that the settlement development in this area generally occurs through the cooptation of ricefield.



Change of Permanent Inundation Size in the Study Location from 2020-2035 (in Ha) (Author Team, 2020)



Changes in Farthest Inundation Distance in the Study Location by 2020-2035 (in km) (Author Team, 2020)

B. Permanent Inundation and Farthest Inundation

Permanent inundation is the type of inundation that permanently inundates the land use on it. The inundation is formed when the land level in that area is situated below the average sea level, so that the inflowing water cannot flow out. With regard to decadal prediction and RCP 4.5 projection, there won't be any difference in permanent inundation size. Whereas, the farthest inundation reflects the spatial distribution of potential inundation that might take place due to flood and tidal flood, yet with subsidable characteristics.

The spatial inundation modelling results show that there will be a **significant change in permanent inundation in the study location**, which is 1,478 Ha during baseline year, to 5,721 Ha by the end of the projection period.

By 2025, the **expansion of permanent inundation will be heading toward eastern and southern part of the study location**. It is visible that the inundation will reach *Kelurahan* Tirta in the south and some parts of *Kelurahan* Padukuhan Kraton and Pasir Kraton Kramat in the east

By 2035, the expansion of permanent inundation will be heading further south and reach some parts of Villages of Kertijayan and Simbangkulon in Pekalongan Regency, and *Kelurahan* Kalibaros and Kuripan Yosorejo in Pekalongan City.

The land subsidence rate is very high in the coastal and downstream areas, which influence significantly the formation of the permanent inundation, in addition to being contributed by the sea level rise and current.

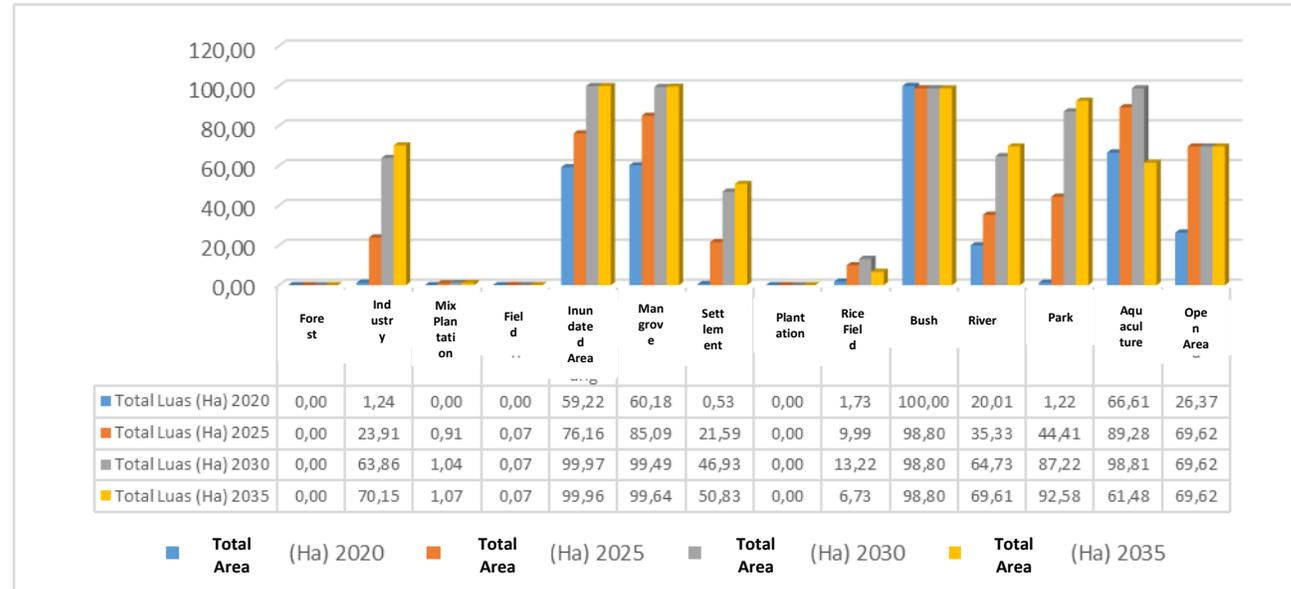
With regard to the farthest inundation, the projection results show that by 2035, the inundated area size will reach 5,700-5,900 Ha (using the decadal prediction and RCP 4.5 projection). The occurrence of inundation is the impact of interaction between various factors: land subsidence, rain intensity, current, and sea level rise.

Specifically for RCP 4.5 projection scenario, there is no changes in the farthest inundation size from 2025-2030 and 2030-2035 periods. During the period, there will be no changes in the farthest distance affected both in decadal prediction as well as RCP 4.5 projection.

The affected distance of the farthest inundation in the baseline year is found to be 4.2 km away from the shore. **By 2025, the distance of the farthest inundation in decadal prediction and RCP 4.5 projection show a rather insignificant difference from each other, namely 7.5 km and 7.55 km from the shore, consecutively.** Both models show that the inundation can reach Kelurahan Degayu, Kuripan Yosorejo, Noyontaansari, and Jenggot.

By 2035, the farthest distance of affected area will increase up to 8.5 km and 9.4 km from the shore consecutively for decadal prediction and RCP 4.5 projection. In this period, for decadal prediction, it can be seen that the permanent and farthest inundation are spatially intersected; with farthest spot of inundation reaching Villages of Simbangwetan and Wonoyoso, as well as *Kelurahan* Sokoduwet and Kuripan Kertoharjo.

Meanwhile, RCP 4.5 projection in the same period shows that the farthest inundation might reach *Kelurahan* Kuripan Kertoharjo, *Kelurahan* Sokoduwet, and Wonoyoso Village.



Proportion of Permanently Inundated Area to the Total Size Per Land Use Classification (Author Team, 2020)

C. Land Use Affected by Inundation

Comparing the spatial distribution of land use with the distribution of permanent inundation, it can be seen that **periodically there is an increase of the affected area size, particularly related to the tidal flood, mangrove, bush, and park land uses.** In fact, by the end of projection period, **>90% of the areas of the four land uses will be covered by permanent inundation.**

Further attention is required for the high proportion of the **affected area (>50%) for settlement, fish pond, open land, and industrial land uses.**

The increase of the affected settlement area size increases gradually from 0.53% in 2020, 21.59% by 2025, 46.9% by 2030, to **50.83% by 2035**, and it shows that the areas projected to be developed into settlement area are potentially located in areas vulnerable to permanent inundation.

Since settlement is a basic need for the population which number will keep increasing over time, an appropriate spatial planning and adequate mitigation plan are required.

The urgency to control and mitigate the development of settlement area becomes even more critical upon seeing the spatial distribution of farthest inundation and land use, particularly for the period of 2020-2025 and 2025-2030. In both periods, **the farthest inundation might inundate approximately 48-49% of the settlement land use, while permanent inundation ranges between 21-46%**. Mitigation measures are needed to maintain the sustainability of domestic and non-domestic activities in the settlement areas affected by farthest inundation.

Mitigation measures, control measures and zonation arrangement are also needed for areas projected to serve as fish pond and industrial land uses. This will become important since the two land use are strongly related to the community's livelihood, in addition to contributing to the local GRDP.

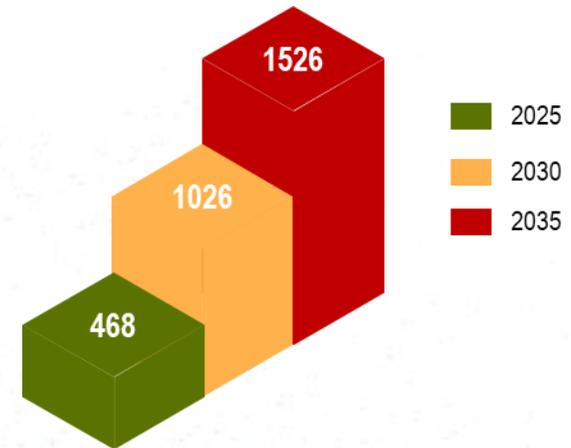
Open land, on the other hand, is commonly used for development of developed and non-developed areas. However, looking at the condition that >60% of this land use might potentially be permanently inundated by 2035, there needs to be an appropriate development plan for open lands that are potentially inundated.

Previously it has been stated that >90% of the tidal flood land use will be permanently inundated by the end of 2035. The inundated area will increase gradually in every period of projection. **The areas with intersection between tidal flood and permanent inundation areas will be the lands with high probability to be inundated throughout the period.**

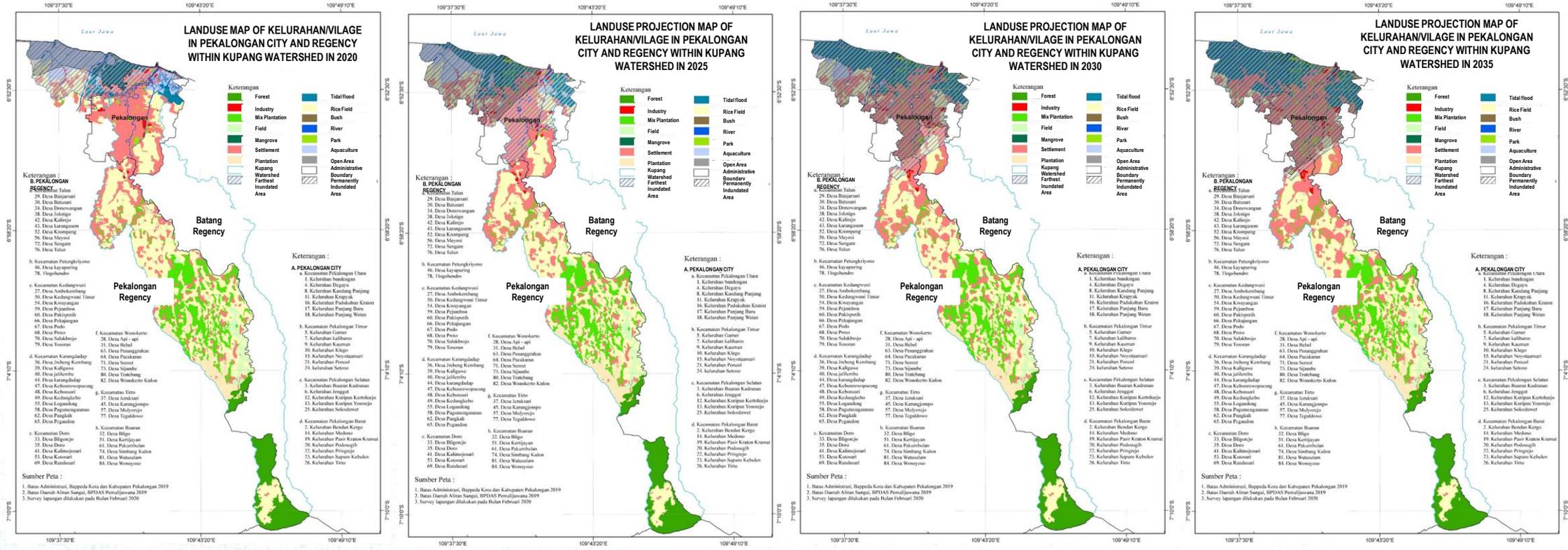
The analysis shows that **468 Ha of land have high probability to be completely inundated throughout the period by 2025**. The land uses with high potential to be inundated are generally **settlement, fish pond, and park**, other than the existing lands that are permanently inundated lands during baseline condition. **By 2030, the inundation with highest probability might expand up to 1,026 Ha**, with the largest addition of inundated land use to be the **fish pond in the west side, as well as ricefield, settlement, and industry in the coastal area and east side** of the study location.

By 2035, the size of high probability inundation will increase up to 1,526 Ha, which will inundate the ricefield and fish pond areas in the west side and ricefield in the east side of the study location.

The areas with high probability need to be prioritized in any flood and tidal flood control measures. From the types of land with increasing size of inundation in every period, it can be seen that the fish pond and ricefield are two most dominant land uses. Therefore, an appropriate strategy in economic sector is critically needed to ensure that the local community's and area's economic growth will not be hindered by the loss of land.



Change of Total Area of High Probability Inundation in the Study Location (in Ha) (Author Team, 2020)



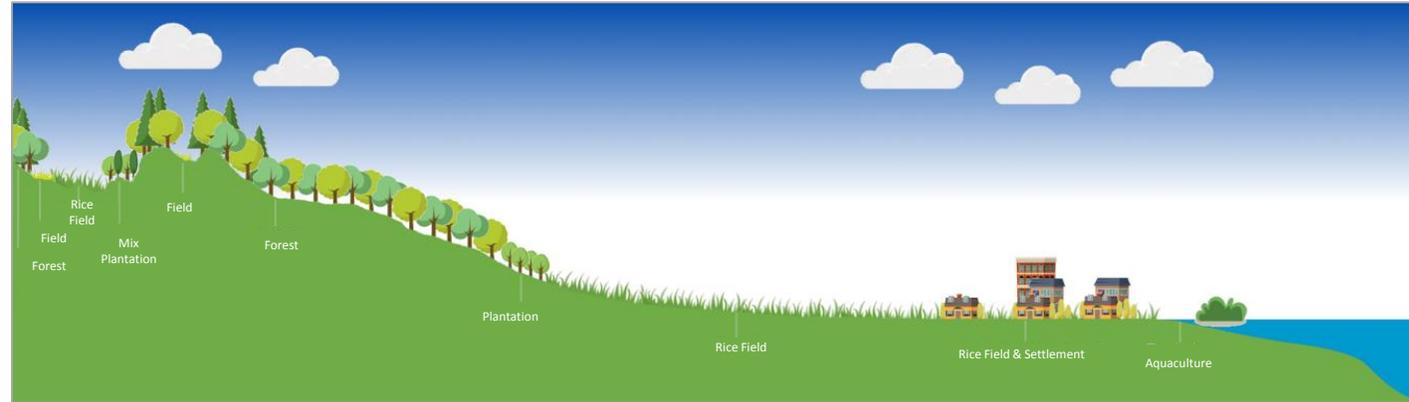
Potential Impacts of Permanent Inundation and Farthest Inundation to Land Use in Baseline Condition (left), by 2025 (middle), and by 2035 (right) with *RCP 4.5 Projection* (Author Team, 2020)

5.4 | Risk in Landscape Context

Risk analysis on landscape context in this study was conducted to identify the influence of landscape change toward the risk experienced by the study location, particularly those related to the issue of water resources management. The way climate variability and changes of water catchment area's function in a watershed system will influence the hydrological system in that particular watershed.

In carrying out the risk analysis, the landscapes covered in the study scope are not only those located within Kupang Watershed, but also the entire areas of Pekalongan Regency and City so as to capture the interaction within the system more comprehensively.

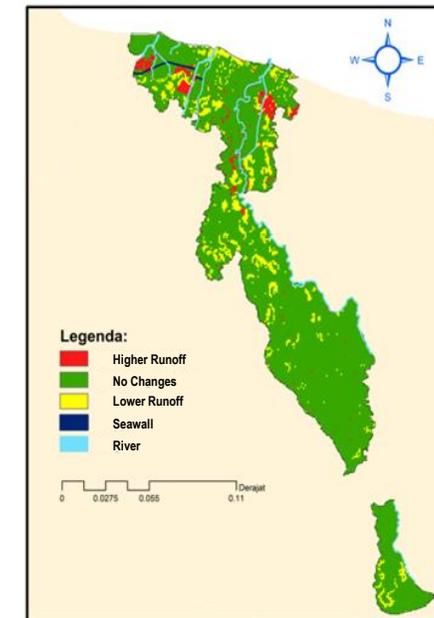
By looking at the domination of land cover per landscape segment, it can be seen that the upstream area is spatially still dominated by the forest which definitely has rather high infiltration rate, thus it can be said that the upstream segment's capacity in absorbing water is still fairly well. The land use projection also shows that until 2035, the forest land use will still dominate the upstream area. The condition causes an increase in size of areas with lower runoff value than that of baseline condition.



Landscape in Each Segment in Baseline Condition (Author Team, 2020)

What should be highlighted in this segment are the areas dominated by ricefield/secondary crop land uses. The value of surface runoff in this land is higher than that of forest. This condition will not only lead to an increase of flood potential in the middle and downstream areas during extreme rain, but will also decrease the number of water that will infiltrate into ground water reserve. Thus, the issue will not only occur during rainy season, yet also during dry season. The climate prediction shows that there are years where R20mm index in the upstream area is below normal, so that there will be an opportunity to reduce the rain intensity, although the CDD projection value relatively won't undergo any significant changes.

To anticipate such a condition, there needs to be appropriate upstream area management measures to ensure that the opposite scenario from that of land use projection will not take place. The size of forest area must be preserved and not coopted by any other land use, which would in turn disrupt the upstream's ecological functions.

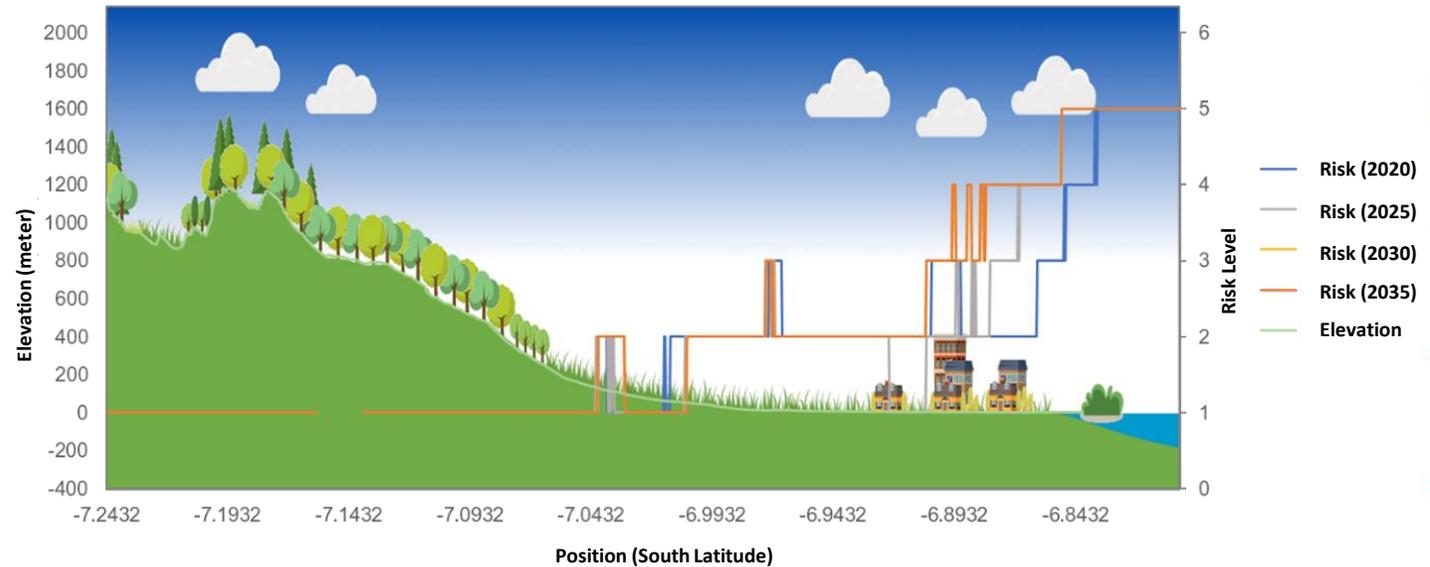


Changes in Runoff Value by 2035 Compared to 2020 (Author Team, 2020)

In the upstream-middle areas transition segment, the land use is dominated by plantation; while the **middle area is dominated by ricefield**, hence settlement area can also be found within. As mentioned previously, ricefield has higher runoff coefficient than that of forest, thus there is potential flood to occur in the segment, which in turn will affect the areas under. The flood events can bring about negative impacts to the economic activities going on in the area. **Flood can lead to harvest failure and crop damage, which leads to decrease of ricefield productivity.**

The **increasing risk** for the middle segment which is dominated by ricefield is also **influenced by the potential drought hazard**, which in Indonesian context is usually caused by **El Nino or IOD positive**. The increasing drought hazard will lead to the decrease of agriculture's productivity and thus farmers' well-being.

For middle segment, the mitigation might be focused on villages with high or very high vulnerability level, without taking into account the flood risk level. This is because the village is categorized as having high risk to various disaster events (in addition to flood), such as drought, landslide, etc.; thus it is very crucial to prepare the village in facing various threats.



Elevation and Risk Level Profile from Upstream to Coastal Area of Pekalongan (Author Team, 2020)

Changes in landscape pattern does not only influence the water quantity that infiltrate and overflow throughout the watershed, but also the water quality going through every segment. The change might increase the amount of pollutant and foster the declining quality of river water since the **landscape pattern contributes to control the biogeochemical and physical process of a watershed**. In Kupang Watershed, declining quality of river water takes place due to the contamination by waste water and solid waste from industrial and settlement activities.

As an edge of a watershed, **the issue of increasing runoff and decreasing water quality bring about the highest impacts to the downstream and coastal segments**. The segment will receive runoff from the upper area, and will also be constrained by the issue of limitation of surface water.

In the study location, **the downstream segment is dominated by settlement and ricefield land uses; with highest concentration of settlement was found in the urban area**. The land use projection shows that there will be an increase in land use conversion from ricefield into settlement, industry, and fish pond.

The **potential land use conversion** will lead to various **impacts**, particularly upon looking at the increasing flood **risk trend in downstream and coastal areas**. By the end of the projection period, the risk level in this segment is dominated by high to very high levels. The impacts will be, among others, the increasing surface runoff in the area, which is caused by the expanding developed areas, expansion of inundation area, and the increasing number of affected population.

Realizing the interconnection between upstream, middle, and downstream areas, the mitigation in downstream and coastal areas cannot be undertaken separately, yet rather shall be integrated with the management of the upper segment.

5.5 | Preliminary Recommendation

By taking into account risk analysis conducted, the study found that the measures to control flood risk cannot be carried out partially in every watershed segment. The interconnection between upstream, middle, and downstream areas further highlights the need to apply holistic and integrated approaches in developing policy framework and flood risk control programs in Kupang Watershed. Flood risk control cannot be conducted only by using disaster approach, yet also needs to consider a comprehensive landscape perspective from upstream to coastal areas.

Departing from that perspective, flood risk control measures in the Kupang Watershed will need the following:

- ☑ Applying holistic approach such as Integrated Water Resource Management (IWRM), Ecosystem Management (EM), and Sustainable Landscape Planning (SLP). The three approaches consider all aspects of problems related to water resources in simultaneous manner, including landscape ecology, adaptive management, and land use conversion.
- ☑ Taking into account the landscape characteristics in each segment, the potential of land use conversion that might take place and the impacts of interaction between land uses with hazard (including climate variability) in the segment.
- ☑ Climate variabilities that require attention are not only the wet extreme condition which might cause flood, but also potential drought that influences the availability of water in the Pekalongan Regency and City. Unlike the flood that affects limited area, drought has wider impacts and might influence the areas unaffected by flood. Thus, if an area has a rather high vulnerability level, it will potentially have higher risk of drought.

- ☑ Developing an early warning system containing information on impact and risk-based weather and climate prediction. The system needs to be developed simultaneously with the community awareness building efforts to use the information, as part of the community adaptive capacity building measures.
- ☑ Giving particular attention to the areas with high and very high vulnerability level in the coastal and non-coastal areas, through adaptive capacity building that is conducted in parallel manner with efforts to decrease of sensitivity and exposure levels. The efforts must be carried out in line with the infrastructure construction and other efforts to reduce disaster risk.
- ☑ Strengthening ecological functions of the coastal area, particularly in areas with mangrove ecosystem to preserve the physical, chemical, biological, economic, and other functions that can be given to the coastal area and water area.

To obtain more accurate recommendations and ones that are in harmony with the local's interest and urgency, the preliminary recommendation will be articulated deeper through a series of discussion processes with various stakeholders and follow-up analysis. The enrichment to this recommendation will be put into a separate Strategic and Policy Recommendation document from this study document.

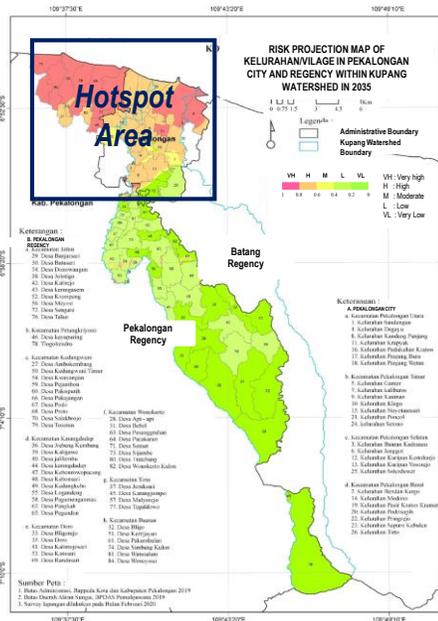


Chapter 06.

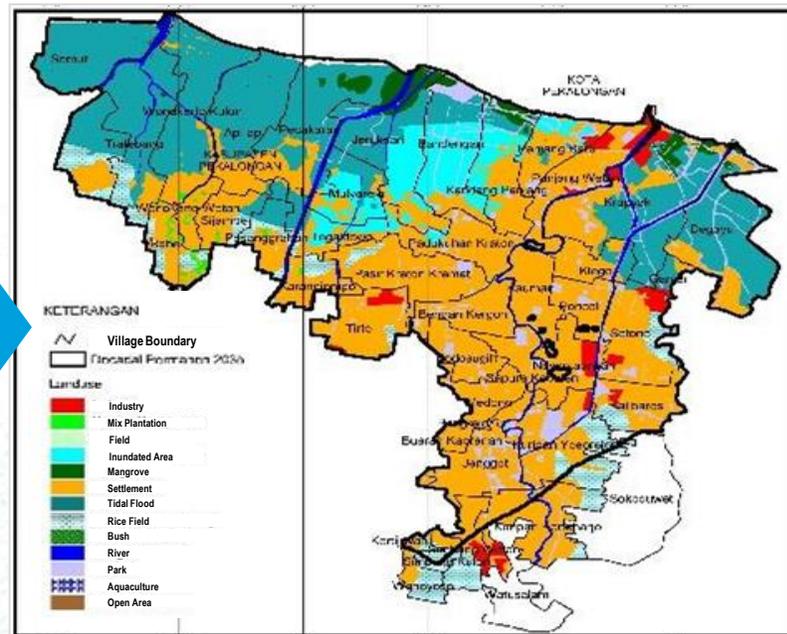
IMPACT ANALYSIS OF ECONOMIC AND NON-ECONOMIC LOSS

6.1 | INTRODUCTION OF IMPACT ANALYSIS OF ECONOMIC AND NON-ECONOMIC LOSS

Flood risk projection shows that there are **42 villages/kelurahan** spread over 7 sub-districts affected by inundation in Pekalongan Regency and City which have a **high and very high risk level**. Considering the urgency, these 42 villages/kelurahan were then selected as hotspot areas for further analysis under this study, which is the impact analysis of economic and non-economic loss due to flood risk. The seven sub-districts that become hotspot areas are Wonokerto, Tirta and Buaran in the Pekalongan Regency; and East Pekalongan, North Pekalongan, West Pekalongan, and South Pekalongan in the Pekalongan City.



Flood Risk Projection Map of Pekalongan Regency and Pekalongan City in 2035



Permanent Inundation Overlay Projection Map with Land use in 2035 in Pekalongan Regency and Pekalongan City

Livelihood Vulnerability Index Analysis (LVI)

Community Risk Characteristics and Perception Analysis

Economic and Non-Economic Loss Analysis

6.2 | Location Profile of Hotspot Area

A. Wonokerto Sub-district, Pekalongan Regency

Wonokerto sub-district is located on the north coast of Pekalongan Regency. This sub-district faces a combination of **tidal flooding, urban flooding and river flooding**. In the last decade, **all rice fields in the villages affected by tidal flood in this sub-district have vanished or are not fully operational**. Permanent inundation is formed at various areas due to flooding and the ineffectiveness of the area's drainage system. The frequency of flooding in this sub-district reaches 5-6 times per year with an average inundation height of 50 cm. Increases of the height of surfaces (such as road, soil level, house) around the settlement area is not a rare sight in this sub-district. **But then this action has led to the formation of new inundation points that took a relatively long time to recede when it rains.**

The **seawall** that separates the permanently inundated area in the north and the dry area in the south is known to have functioned quite effectively during tidal flooding. However, **this seawall system has not been integrated with the Mrican River embankment system**. The existence of this river embankment blocks the flow of water to the sea during high rainfall, while the capacity of the five pumps that should be the key to channel the water to the sea is not sufficient to discharge water from the river body into the sea, so that river flooding is unavoidable. This non-integrative embankment system results in ineffective flood control in this sub-district.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>SEMUT</p> <ul style="list-style-type: none"> Population 2,100 inhabitants Area 2.24 km² Main professions: laborers, fishermen, farmers, employees. Flood-related infrastructure: seawall on the north side and river embankment on the Mrican River 	 <p>Permanent inundations in Semonet, Semut Village</p>	
<p>TRATEBANG</p> <ul style="list-style-type: none"> Area 2.02 km² Population 2,364 inhabitants Main professions: fishermen, traders, laborers, employees, farmers. Flood-related infrastructure: seawall (part of Segment 1) with 2,850 meters in length and Tratebang River management 	 <p>The condition of settlement area in Tratebang Village that lives 'with water'</p>	
<p>WONOKERTO</p> <ul style="list-style-type: none"> Area 1.48 km² Population: 6,498 inhabitants Main professions: laborers, services, employees, fishermen, farmers. Flood-related infrastructure: seawall (segment 1) 	 <p>Poor environmental conditions due to tidal flood in Wonokerto Kulon Village</p>	
<p>PECAKARAN</p> <ul style="list-style-type: none"> Area: 2.10 km² Population: 4,047 inhabitants Main professions: fisherman, merchant, service, employee, employee. Flood-related infrastructure: Seawall (segment 2) There are 3 pumps, but only 1 that is functioning. It discharges water from the land into the Sengkarang River. 	 <p>Aquacultures are still operated in Pecakaran Village</p>	

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
API-API <ul style="list-style-type: none"> Area 2.21 km² Population: 5,014 inhabitants Main professions: self-employed, farmers, farmworkers, handymen, employees Flood-related infrastructure : seawall and river embankment 	 <p>Inundated area around settlements and aquaculture area in Api-Api Village</p>	
SIJAMBE <ul style="list-style-type: none"> Area 0.95 km² Population: 4,776 inhabitants Main professions: farmers, laborers, services, employees Flood-related infrastructure: seawall 	 <p>Inundation in the drainage channel of Sijambe Village</p>	
PESANGGRAHAN <ul style="list-style-type: none"> Area 7.89 km² Population: 2,922 inhabitants Main professions: labours, farmers, fishermen, farmworkers, construction workers, employees, services Flood-related infrastructure: river embankments 	 <p>Long-receding inundation in Pesanggrahan Village</p>	
WONOKERTO WETAN <ul style="list-style-type: none"> Area: 0.42 km² Population: 3,471 inhabitants Main professions: fishermen, merchant, labours, farmworkers, farmers, employees Flood-related infrastructure: seawall 	 <p>Drainage around the settlement area of Wonokerto Wetan Village</p>	
BEBEL <ul style="list-style-type: none"> Area: 1.02 km² Population: 8,566 inhabitants Main professions: fishermen, service, self-employed, farmers, farmworkers, employees Flood-related infrastructure: seawall 	 <p>Drainage that do not run and clogged by garbage in Bebel Village</p>	

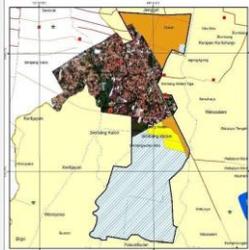
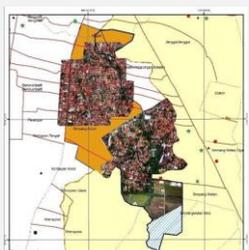
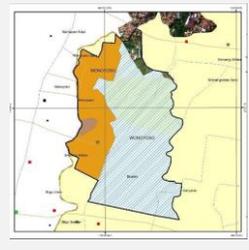
B. Tirto Sub-district, Pekalongan Regency

Tirto Sub-district is a coastal area that borders the Java Sea and the river so that the area is exposed to 2 different types of flood; tidal and river flooding. The frequency of flooding in this sub-district reaches 4-8 times per year with inundation height at a range of 50 cm - 1 m. Pumping system is typically used to discharge inundation water, yet several area with permanent inundation can still be identified in different locations within the sub-district since the drainage system is no longer effective. Flooding have also caused significant land use changes in Tirto sub-district. In 2010 there were still around 218 Ha of rice fields in the sub-district, but by 2020 all rice fields area were inundated and the dryland area significantly decrease.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
JERUKSARI <ul style="list-style-type: none"> Area: 2.18 km² Population: 7,693 inhabitants Main professions: fishermen, farmers, service, labours, merchant, employee. Flood-related infrastructure: seawall (segment 2) 	 <p>Permanent inundation in Jeruksari</p>	
MULYOREJO <ul style="list-style-type: none"> Area: 0.72 km² Population: 3,108 inhabitants Main professions: labour, fishermen, services, employees. Flood-related infrastructure: seawall and river embankment 	 <p>Inundation that was covered by soil in Mulyorejo Village</p>	
TEGALDOWO <ul style="list-style-type: none"> Area: 0.96 km² Population: 3,266 inhabitants Main professions: employees, craftsmen, industrial workers, traders, fishermen, farmers. Flood-related infrastructure: seawall, river embankment, and pump 	 <p>Settlement area in Tegaldowo Village and also flooded and clogged drainage</p>	
KARANGJOMPO <ul style="list-style-type: none"> Area: 0.83 km² Population: 5,286 inhabitants Main professions: industrial workers, traders, employees, farmers. Flood-related infrastructure: seawall 	 <p>Permanently inundated and abandoned house in Karangjampo Village</p>	

C. Buaran Sub-district, Pekalongan Regency

The Buaran Sub-district area is located in the south of Pekalongan City and is an **urban-type lowland**. This area has several rivers that are part of the Kupang watershed and the Sengkarang watershed. Therefore, the types of flooding that experienced by the area are **urban flood and river runoff**. The average inundation height is around 50 cm - 1 m with an average flood frequency of 1-4 times per year. The Buaran **area is a center for the batik industry of various scales, ranging from household scale, small business, medium business, to large industry. The region is also a location for trade and services**. Seeing the connection between flooding and the density of the batik business/industry, an IPAL facility has been built in Simbang Kulon Village in 2019. As one of the centers of economic activity in Pekalongan Regency, flood events certainly disrupted the continuation of economic activity in Buaran sub-district, as well as affecting the daily life of the population, including in the settlement area.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>SIMBANG KULON</p> <ul style="list-style-type: none"> • Area: 1.21 km² • Population: 8,844 inhabitants • Main professions: freelancers, labours, craftsmen, merchants, and employees and farmers. • Flood-related infrastructure: none 	 <p>Orthomosaic photo shows the densely populated (settlement) Simbang Kulon</p>	
<p>SIMBANG WETAN</p> <ul style="list-style-type: none"> • Area: 0.69 km² • Population: 4,805 inhabitants • Main professions: industrial workers, services, merchants, employees, employees • Flood-related infrastructure: none 	 <p>The river located to the east of Simbang Wetan Village</p>	
<p>KERTIJAYAN</p> <ul style="list-style-type: none"> • Area: 0.91 km² • Population: 6,339 inhabitants • Main professions: employees, craftsmen, industrial workers, traders, fishermen, farmers. • Flood-related infrastructure: none 	 <p>Dense settlement of Kertijayan Village</p>	
<p>WONOSOYO</p> <ul style="list-style-type: none"> • Area: 0.83 km² • Population: 4,436 inhabitants • Main professions: industrial workers, traders, employees, employees, farmers, farmworkers, entrepreneurs. • Flood-related infrastructure: none 	 <p>Settlements in Wonoyoso Village</p>	

D. North Pekalongan Sub-district, Pekalongan City

This sub-district is one of the areas **most affected by tidal flooding in the north coast of Java**. It has been facing tidal flooding for over a decade that resulted in significant changes in the area. **Almost 100% of its northern part has turned into 'ocean' due to permanent inundation**. The construction of seawall by the central government and coastal management program by the provincial government have not been effective to protect them from tidal flooding, while on the other hand, the flow of surface runoff in the urban area has **difficulty in finding outlets and channels to the sea due to the existence of the said seawall**. Thus flood management in the area is considered as not yet optimal. The frequency of flooding in this sub-district reaches 5-8 times per year with an average inundation height of 1 m.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>BANDENGAN</p> <ul style="list-style-type: none"> Area: 2.21 km² Population: 6,250 inhabitants Main professions: laborers, merchants, self-employed, employees, fishermen, services, employees, and farmers. Flood-related infrastructure: seawall and coastal embankment. 	 <p>Tidal flooding event in Bandengan in March 2020</p>	
<p>KANDANGPANJANG</p> <ul style="list-style-type: none"> Area: 1.51 km² Population: 13,548 inhabitants Main professions: laborers, farmworkers, traders, self-employed, artisans, servicemen, employees, fishermen, farmers and scavengers. Flood-related infrastructure: coastal embankment 	 <p>Inundation that cannot flow to the sea and turned into ponds in Kandangpanjang</p>	
<p>PANJANG WETAN</p> <ul style="list-style-type: none"> Area: 1.41 km² Population: 13,542 inhabitants Main professions: merchant, self-employed, laborer, employee, fisherman, retiree, handyman, scavenger, and service. Flood-related infrastructure: river embankment. 	 <p>Flooding due to overflow of Loji River in Panjang Wetan</p>	

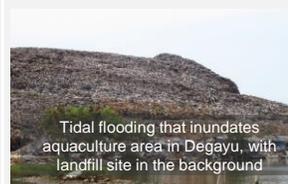
General and Demographic Conditions

Photo (Source: observation 2020)

Location Map

DEGAYU

- Area: 3.37 km²
- Population: 8,102 inhabitants
- Main professions: employees, traders, services, fishermen, scavengers, farmworkers, farmers, laborers, handymen.
- Flood-related infrastructure: none.



PANJANGBARU

- Area: 0.94 km²
- Population: 10,329 inhabitants
- Main professions: housewives, freelancers, self-employed, merchants, fishermen, fishing workers, employees, handymen, and farmers.
- Flood-related infrastructure: coastal embankment



KRAPYAK

- Area: 3.79 km²
- Population: 19,665 inhabitants
- Main professions: employees, self-employed, merchants, fishermen, retirees, farmworkers
- Flood-related infrastructure: coastal embankments, river embankments.



PADUKUHAN KRATON

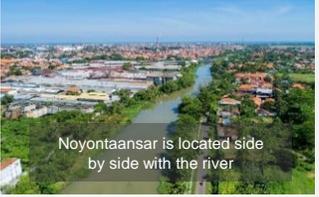
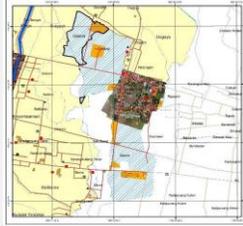
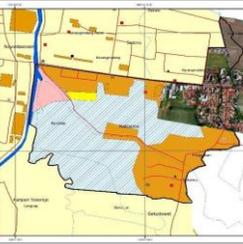
- Area: 1.65 km²
- Population: 13,379 inhabitants
- Main professions: self-employed, merchant, employee, industrial worker, service, handyman, clerk, fisherman, doctor.
- Flood-related infrastructure: coastal embankment.



E. East Pekalongan District, Pekalongan City

This area is considered as an **urban area with agriculture and industry as the predominant land use, in addition to settlement area**. Their administrative area does not have a coastline and thus not affected by tidal flooding, but they are often affected by **river overflow and urban flooding during high rainfall**. The average inundation height of inundation is around 20-50 cm with an average flood frequency of 3-4 times per year. Kelurahan Poncol and Noyontaansari are the most densely populated kelurahan in this sub-district.

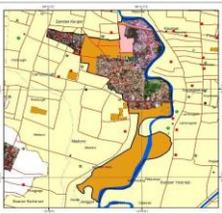
General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>KAUMAN</p> <ul style="list-style-type: none"> Area: 1.46 km² Population: 11,575 inhabitants Main professions: private employees, traders, self-employed, services, handymen, retirees, employees, scavengers, fishermen Flood-related infrastructure: river embankment 	 <p>Aerial photo of Kauman</p>	
<p>PONCOL</p> <ul style="list-style-type: none"> Area: 0.62 km² Population: 16,711 inhabitants Dominant professions: merchant, self-employed, employee, retiree, handyman, service, fisherman and farmworker. Flood-related infrastructure: river embankment. 	 <p>Aerial photo that shows high density of buildings in Poncol</p>	
<p>KLEGO</p> <ul style="list-style-type: none"> Area: 0.85 km² Population: 9,791 inhabitants Main professions: merchant, self-employed, employee, service, scavenger, handyman, fisherman and farmworker. Flood-related infrastructure: river embankment. 	 <p>Floods that often occur due to clogged drainage in Klego</p>	

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>GAMER</p> <ul style="list-style-type: none"> Area: 1.70 km² Population: 4,573 inhabitants Main professions: merchant, self-employed, farmworker, employee, clerk, fisherman, service and scavenger. Flood-related infrastructure: river embankment 	 <p>In the background is the flooded rice field in Gamer</p>	
<p>NOYONTAANSARI</p> <ul style="list-style-type: none"> Area: 0.90 km² Population: 13,324 inhabitants Main professions: merchant, self-employed, laborer, employee, retiree, handyman, scavenger and fisherman. Flood-related infrastructure: river embankment. 	 <p>Noyontaansari is located side by side with the river</p>	
<p>SETONO</p> <ul style="list-style-type: none"> Area: 1.91 km² Population: 10,395 inhabitants Main professions: employees, freelancers, farmworkers, handymen, fishermen, retirees, services, and scavengers. Flood-related infrastructure: river embankment 	 <p>Some inundated areas in Setono</p>	
<p>KALIBAROS</p> <ul style="list-style-type: none"> Area: 2.08 km² Population: 7,009 inhabitants Main professions: employees, self-employed, merchants, services, handymen, retirees, farmers, fishermen, and farmworkers. Flood-related infrastructure: river embankment. 	 <p>Aerial photo of Kalibaros</p>	

F. West Pekalongan Sub-district, Pekalongan City

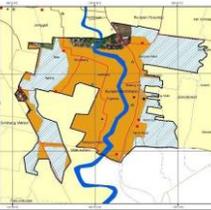
This area is an urban area with a variety of land use, including **settlements, public infrastructure facilities, industry, services as well as trade and agriculture**. Flooding in the area often a result of **the expansion of tidal inundation from the north and river overflow runoff on the east and west side of this sub-district**. The inundation height is around 50 cm in average, with flooding frequency between 1-6 times per year. With the high density and variety of activities that taken place in the area, it is critical to consider aspects that contribute to flood risk and also the potential derivative loss in formulating efforts to reduce flood risk in this sub-district.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>MEDONO</p> <ul style="list-style-type: none"> Area: 1.16 km² Population: 14,958 inhabitants Main professions: employees, self-employed, services, retirees, teachers, fishermen and scavengers. Flood-related infrastructure: none. 	 <p>Typical alley heading towards the settlement area behind commercial area in Medono</p>	
<p>PODOSUGIH</p> <ul style="list-style-type: none"> Area: 0.81 km² Population: 9,965 inhabitants Main professions: employees, traders, self-employed, retirees, handyman, services Flood-related infrastructure: none. 	 <p>Settlements in Podosugih</p>	
<p>TIRTO</p> <ul style="list-style-type: none"> Area: 1.41 km² Population: 10,894 inhabitants Main professions: employees, services, self-employed, merchants, teachers, retirees, farmworkers, and fishermen. Flood-related infrastructure: river embankment 	 <p>The water level of the Meduri River is higher than the surface of settlement area in Tirto</p>	

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>PRINGREJO</p> <ul style="list-style-type: none"> Area: 2.24 km² Population: 18,203 inhabitants Main professions: employees, self-employed, merchants, handyman, retirees, services, farmworkers, fishermen. Flood-related infrastructure: none 	 <p>Aerial photo of Pringrejo</p>	
<p>SAPURO KEBULEN</p> <ul style="list-style-type: none"> Area: 0.96 km² Population: 11,878 inhabitants Main professions: employees, self-employed, merchants, clerks, handyman, retirees, services, fishermen and scavengers Flood-related infrastructure: river embankment 	 <p>Settlements in Sapuro Kebulen</p>	
<p>BENDAN KERGON</p> <ul style="list-style-type: none"> Area: 1.63 km² Population: 15,687 inhabitants Main professions: employees, self-employed, merchants, handyman, retirees, services, fishermen, scavengers and farmers. Flood-related infrastructure: river embankment 	 <p>Inundation in Bendan Kergon</p>	
<p>PASIRKRATON KRAMAT</p> <ul style="list-style-type: none"> Area: 1.84 km² Population: 15,699 inhabitants Main professions: self-employed, merchants, employees, services, handyman, retirees, farmworkers, fishermen, farmers and scavengers Flood-related infrastructure: river embankment 	 <p>Inundation in Pasirkraton Kramat</p>	

G. South Pekalongan Sub-district, Pekalongan City

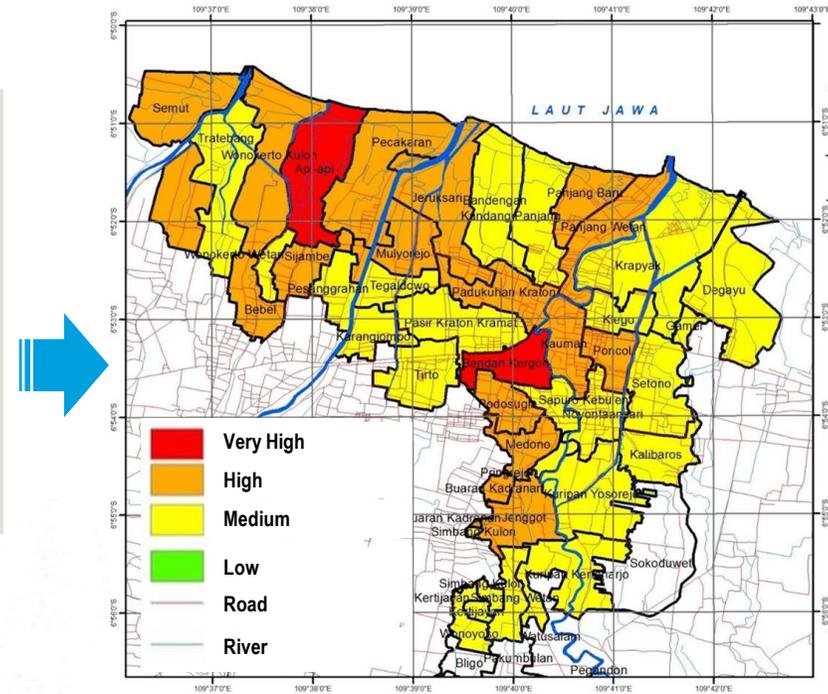
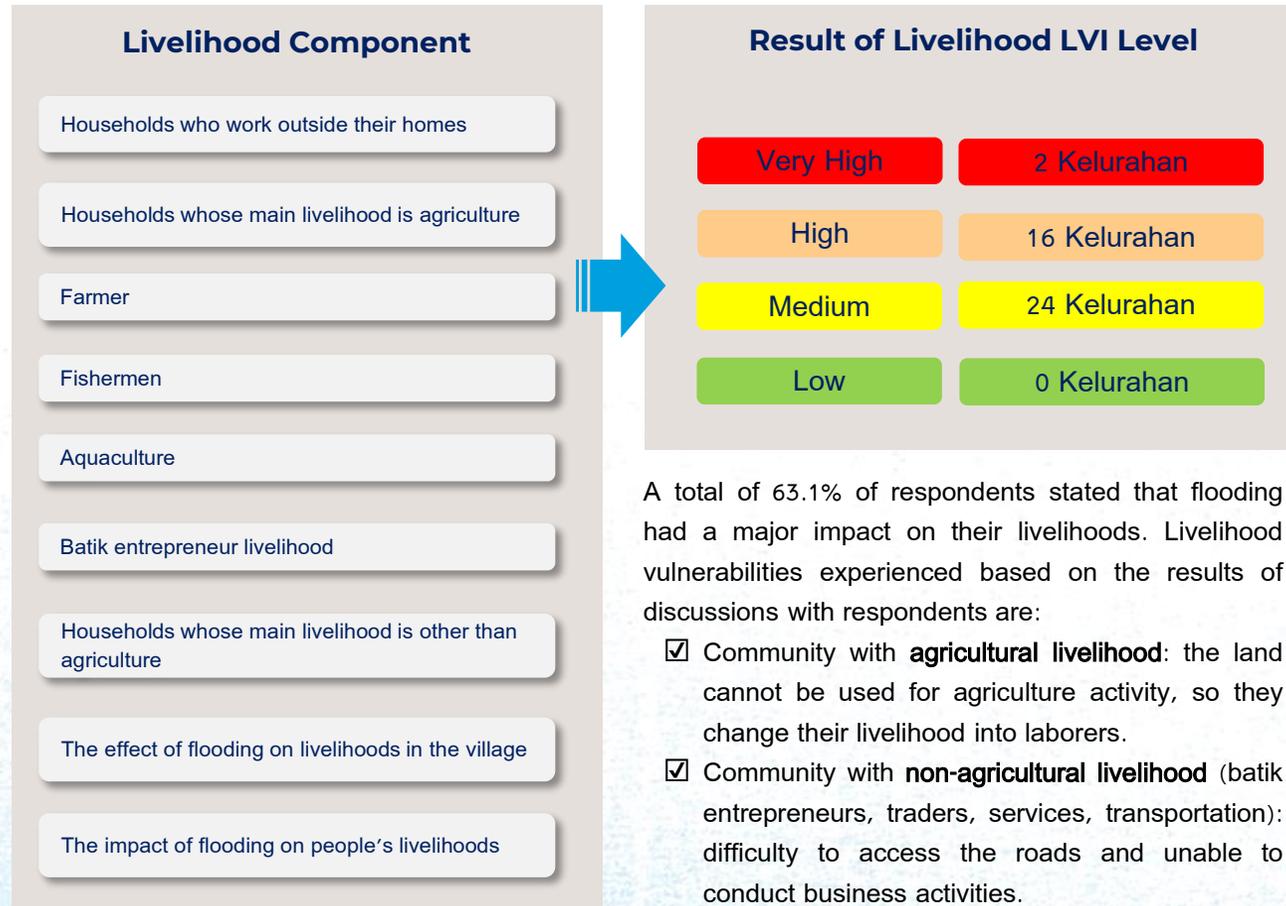
This area is a **relatively dense residential area and is the center of the batik industry in Pekalongan City**, as well as a **trade and service area**. Agricultural land can still be identified in this sub-district, especially those with technical irrigation. Compared to the other sub-districts, **the flood experienced in this area is relatively small** and is mostly caused by high rainfall and inoptimum operations of the current drainage system. The frequency of flooding in this sub-district ranges from 1-4 times per year with an average inundation height of 25-50 cm.

General and Demographic Conditions	Photo (Source: observation 2020)	Location Map
<p>JENGGOT</p> <ul style="list-style-type: none"> • Area: 1.23 km² • Population: 12,319 inhabitants • Main professions: self-employed, merchant, employee, technician, service, retiree, fisherman, farmworker: • Flood-related infrastructure: river embankment 	 <p>River conditions in Jenggot</p>	
<p>BUARAN KRADENAN</p> <ul style="list-style-type: none"> • Area: 1.04 km² • Population: 11,667 inhabitants • Main professions: employees, self-employed, merchants, retirees, handymen, artisans, services, scavengers, farmworkers • Flood-related infrastructure: none. 	 <p>Drainage in Buaran Kradenan</p>	
<p>KURIPAN KERTO HARJO</p> <ul style="list-style-type: none"> • Area: 2.07 km² • Population: 8,029 inhabitants • Main professions: self-employed, merchants, employees, services, handymen, laborers, retirees, farmworkers, fishermen and scavengers • Flood-related infrastructure: river embankment 	 <p>Irrigation canals in Kuripan Kertoharjo</p>	
<p>KURIPAN YOSOREJO</p> <ul style="list-style-type: none"> • Area: 2.26 km² • Population: 12,876 inhabitants • Main professions: employees, self-employed, merchants, handymen, retirees, services, farmworkers and farmworkers • Flood-related infrastructure: river embankment 	 <p>Settlement area and rice fields in Kuripan Yosorejo</p>	

6.3 | Livelihood Vulnerability Index Analysis

According to Shah et al. (2013) the Livelihood Vulnerability Index (LVI) analysis describes the method used to systematically examine the interaction between humans and the physical and social environment. Taking into account the local context and data availability, the components measured for the LVI analysis in this study include: livelihood, sickness and disease, socioeconomic, water needs, disaster relief and management, flood disasters, and food.

A. LVI Analysis based on Livelihood



- ❖ Communities in the Vulnerable Villages/Kelurahan based on livelihood aspect do not only depend on 3 agricultural profiles (rice fields, fishermen, aquaculture) as their main livelihood. They also work as traders, entrepreneurs, services, etc.
- ❖ Agriculture-based livelihood (farming, fishing and aquaculture) is a type of business sector that is closely related and dependent on the condition of natural resources, because these jobs cannot move locations easily like other livelihoods.

B. LVI Analysis based on Sickness and disease

Sickness and Disease Component

COVID affects livelihoods

The Impact of COVID on Livelihoods

The magnitude of impacts of COVID on people's livelihoods

Number of people affected by COVID in the village

Number of people affected by flood-related disease

Family members in the household who suffer from chronic diseases

Household whose family members have not worked for 2 weeks or more due to illness due to flooding

COVID management

Result of Sickness and Disease LVI Level

Very High

2 Kelurahan

High

26 Kelurahan

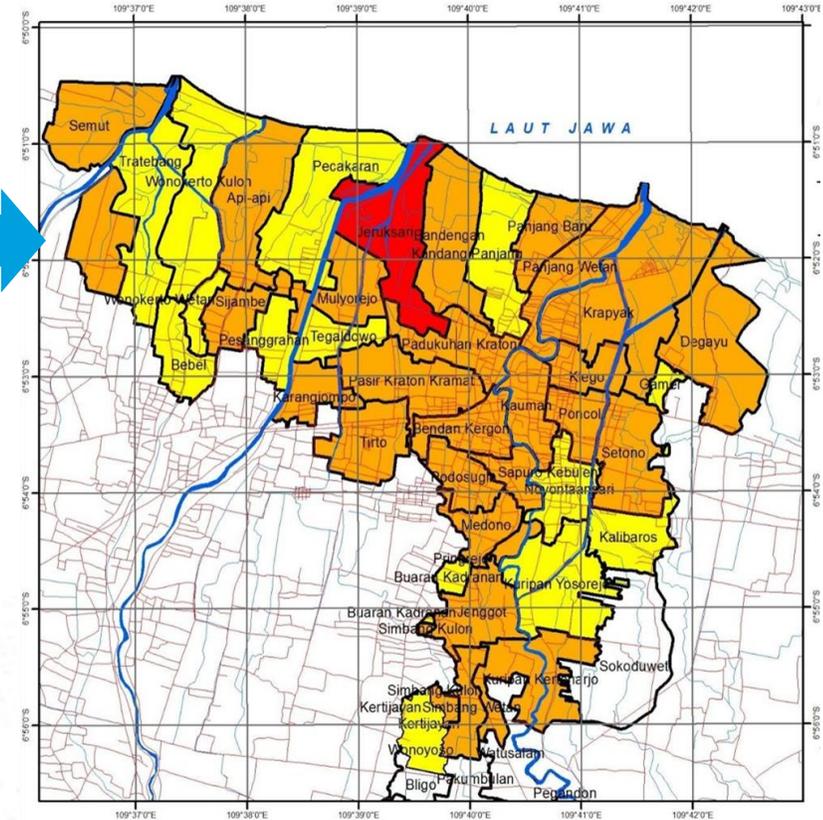
Medium

15 Kelurahan

Low

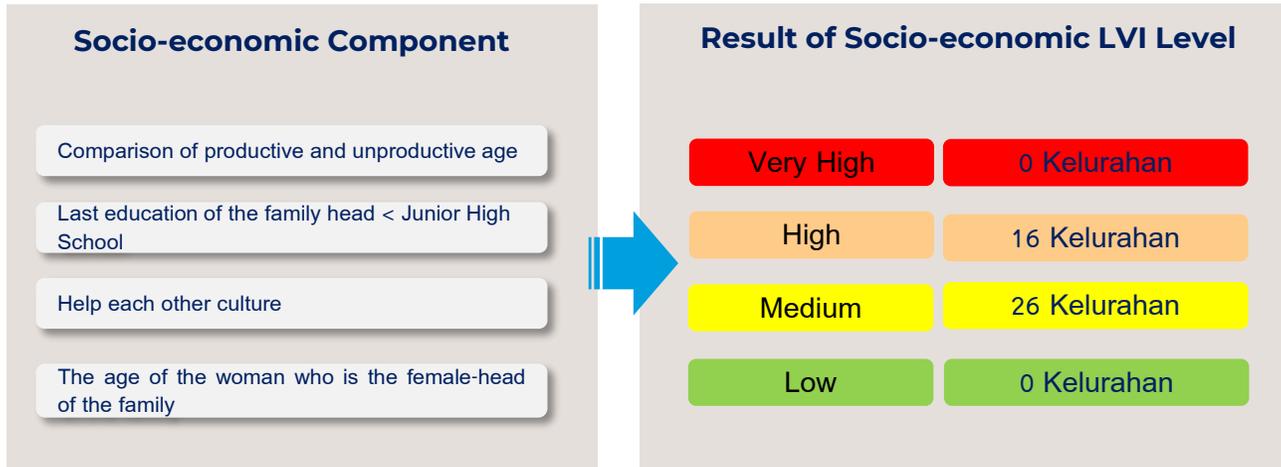
0 Kelurahan

More than 95.24% of the respondents stated that sickness would worsen their quality of life. An example is the incident of COVID-19. The pandemic had crippled the community's economy due to falling market demand which in turn reduces production and subsequently the number of workers. The burden of the community that previously had to deal with flooding impact were exacerbated by the pandemic. The absence of offline works and school activities resulted in a significant decrease in the productivity of traders and tourism activities, so that market absorption of the products decreased.



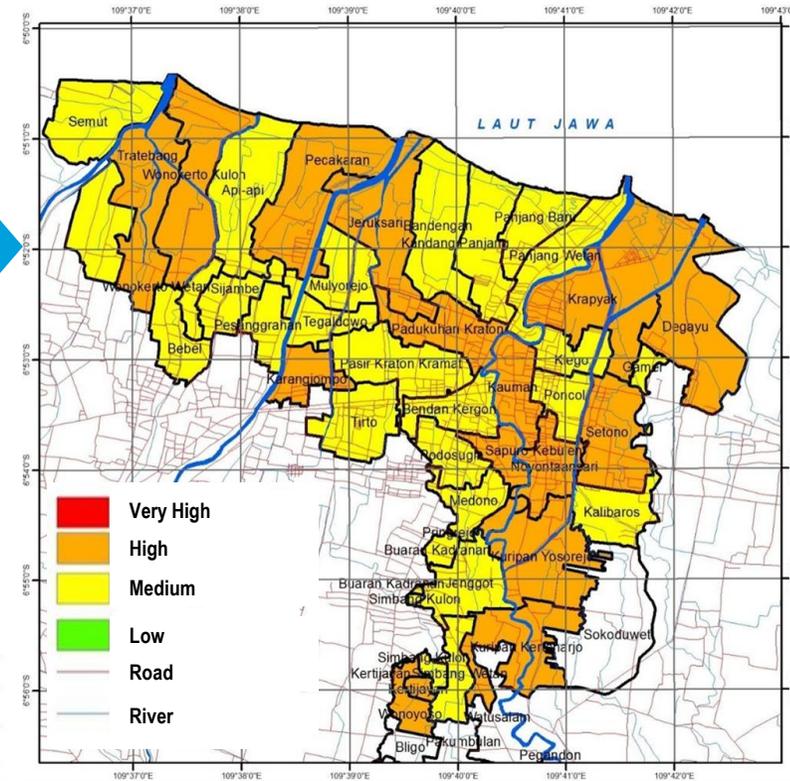
The level of vulnerability to sickness and disease is due to the very few findings presented by the respondents. This shows that sickness and disease caused by floods are not as severe as those caused by the COVID-19 pandemic.

C. LVI Analysis based on Socio-economic



The identification results show that the respondents are dominated by the head of the family with an elementary education level (38.10%). Low education correlates with low understanding of flood risk itself. There are also quite a number of respondents with an unproductive age range (35.71%), so that they are at risk to: livelihoods, income, disaster preparedness and others.

In addition, the cultural aspect of helping each other is also known to have begun to fade, where as many as 70.24% of respondents rarely done and even stopped the culture of helping each other. Gender issues are also identified based on interview with the respondents. Females who are the heads of families are quite high (34.52%). These women have to play a dual role as the head of the family as well as housewives which then place a high burden on them in living their daily lives. This situation thus poses a high vulnerability because they can only spare little attention to matters related to disaster risk.



Analysis shows that there are no villages/kelurahan that categorized as very high based on the level of socio-economic vulnerability

D. LVI Analysis based on Water Needs

Water Needs Component

The primary water source for shower, washing and toilet (MCK) needs of the community

Household that self-collect water because they do not served by the public water system

Household with water access from other public systems

Household with water source from wells, rainwater, and springs?

Household that does not have primary water supply?

Daily water consumption of household

Water needs are supplied by the primary water sources

Alternative water sources

Result of Water Needs LVI Level

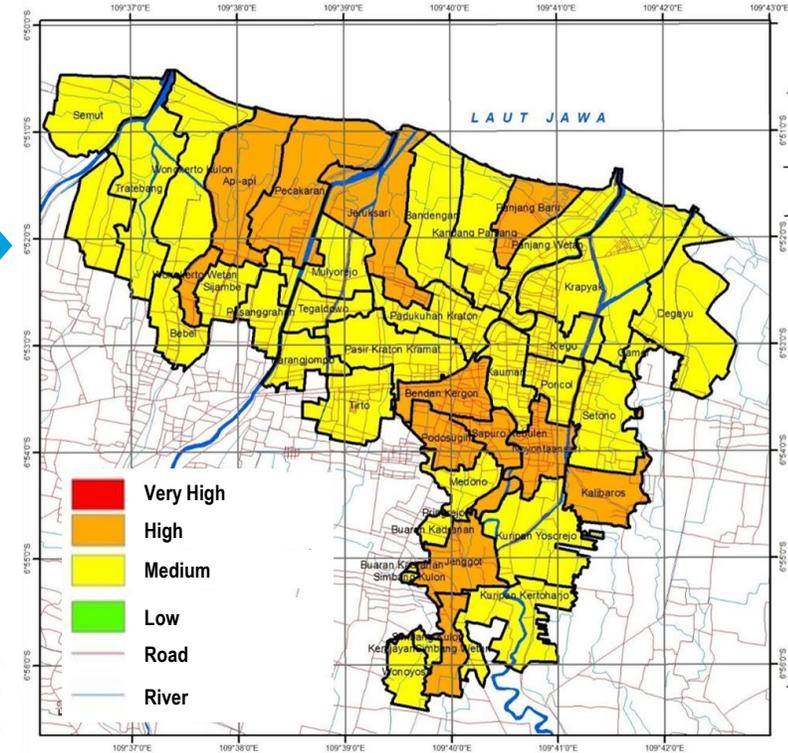
Very High 0 Kelurahan

High 13 Kelurahan

Medium 29 Kelurahan

Low 0 Kelurahan

Based on the identification, around 58.57% of respondents buy water from outside the village/kelurahan to fulfil their daily water needs. Only 25% of the respondents that use water supply from PAMSIMAS for toilet needs, the rest have to use well water that is considered as salty (brackish water due to potential salt water intrusion).



Community will be more vulnerable (based on water needs) if the village/kelurahan that have become their water source for MCK and drinking purposes are hit by flood disaster. Based on the discussion, they usually get/buy water from the neighboring village, but if the particular village is also affected by flooding, then they usually buy from the water tank vendor or get and assistance from the local government.

E. LVI Analysis based on Disaster Relief and Management

Disaster Relief and Management Component

Availability of assistance from the government with regards to flooding in the last 1 year

What kind of government assistance related to flooding in the last 1 year

Household that requested assistance from the government in the last 12 months

Travel time to the nearest health facility

Household with family members in need of care

Result of Disaster Relief and Management LVI Level

Very High 2 Kelurahan

High 2 Kelurahan

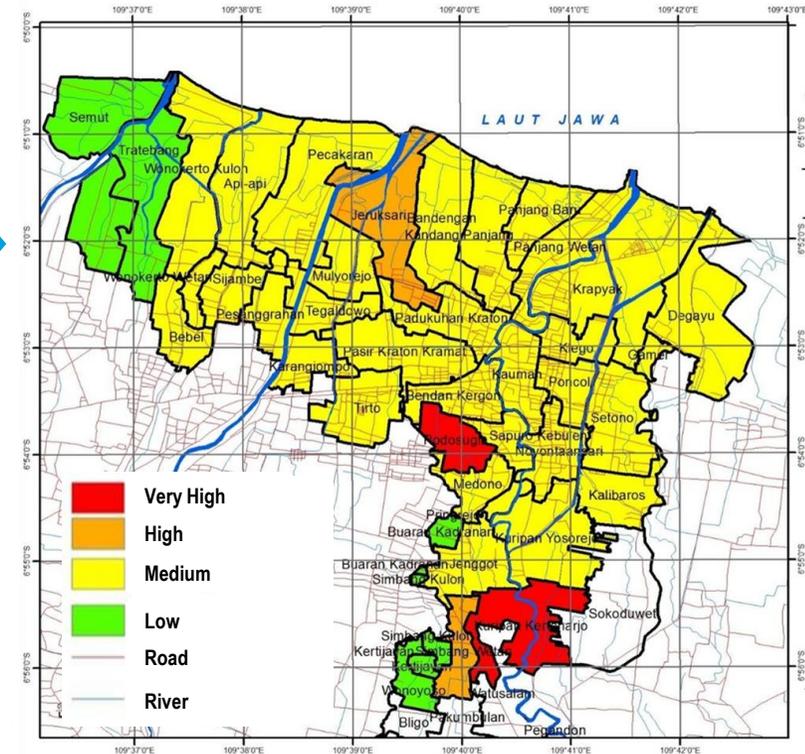
Medium 33 Kelurahan

Low 5 Kelurahan

So far, the community has received disaster relief and management from the government. A total of 90.48% of respondents stated that they received assistance due to floods in the last 1 year (2020). The assistance usually comes in the form of 1-2 types of support, of which 61.90% stated that they only received basic food assistance (logistics) during flood event.

In addition, in the last 12 months around 38.69% of respondents asked for an assistance from the government for house repairment. This kind of repairment (and construction) is usually provided after validation and verification by the village/kelurahan administrative.

Furthermore, regarding access to health facilities during a flood event, the majority of respondents stated that the travel time is usually <10 minutes so there was no accessibility issue here.



Around 15.87% are households with family members who need treatment due to age, physical/mental condition, illness and disability. There are 2 villages that fall into the very high category based on disaster relief and management vulnerability, namely Kuripan Kertoharjo Village and Podosugih Village.

F. LVI Analysis based on Flood Disaster

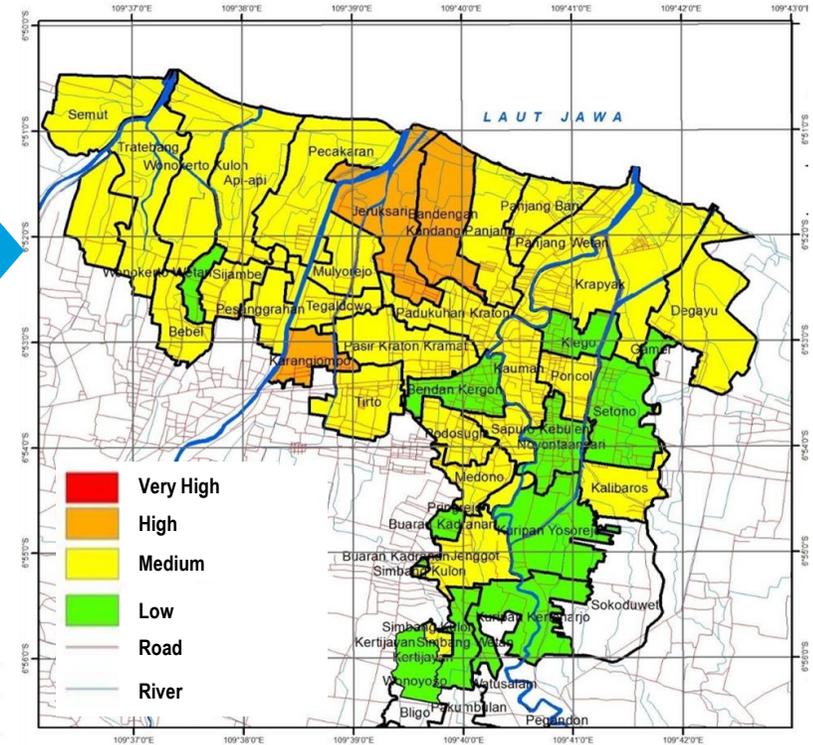
Flood Disaster Component

- Highest flood level since 2019 - 2020
- Lowest flood level since 2019 - 2020
- Increased flood since 2019 - 2020
- Number of flood event in the last 1 year
- Owners who lost their livelihood-related land due to flooding
- Household that lost physical assets during floods
- Household that lost physical assets during floods
- Household injured/died due to flooding in the last 3 years
- Household that demolished its house and rebuilt it
- Household that repairs its house because it was affected by a flood
- Abandoned house hit by flood
- Houses with weak construction to withstand flooding

Result of Flood Disaster LVI Level

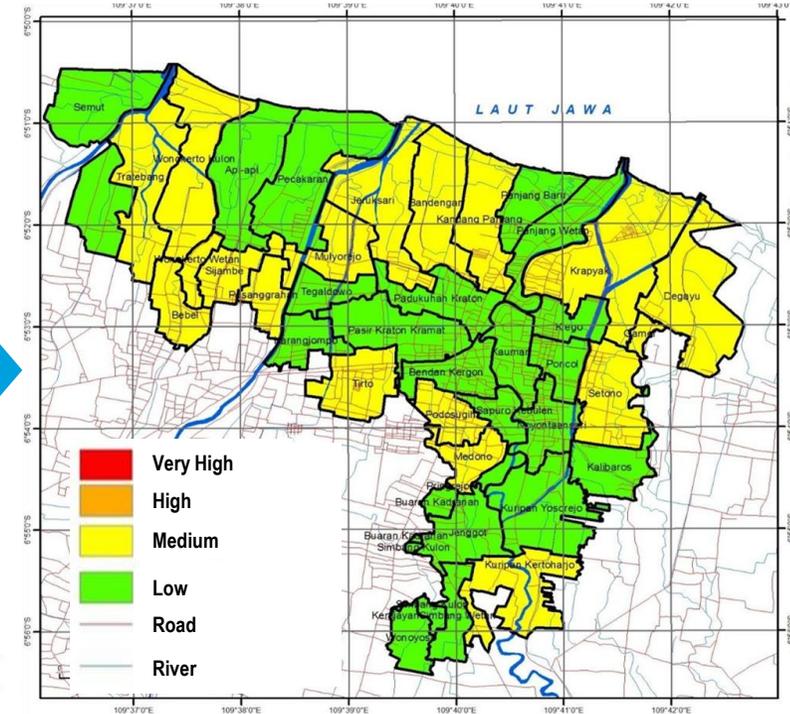
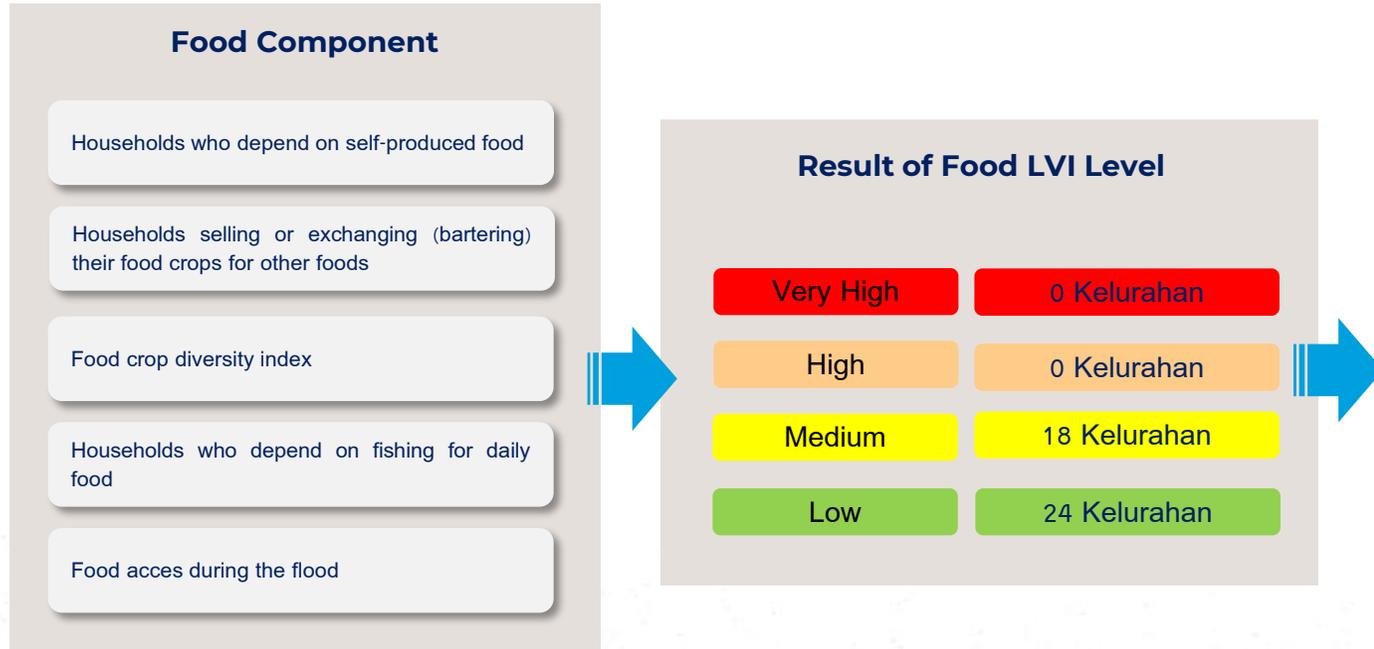
Very High	0 Kelurahan
High	3 Kelurahan
Medium	27 Kelurahan
Low	12 Kelurahan

A total of 33.93% of respondents stated that the highest flood level experienced since 2019–2020. The frequency of flooding in the last 1 year was stated to be > 9 times by 33.33% of respondents. The lowest flooding level of more than 0.5 m has also increased since 2019 – 2020 according to 88.10% of respondents, which indicates that the inundation height continues to increase with every event. In the last 1 year, an increase in inundation as high as <0.5 m was stated to have occurred by 89.29% of respondents, while other respondents stated an increase in the inundation could reach >1 m.



There is no village/kelurahan with a very high level of vulnerability. There are 3 villages/kelurahan with high vulnerability to flood disasters. On average, respondents stated that they were used to flood disasters so that this situation is considered as not a burden to them. As a result, the respondent's level of vulnerability based on flood disaster component is predominantly at medium and low level.

G. LVI Analysis basedn on Food



The food vulnerability component has the lowest level of vulnerability compared to other LVI components since food availability is not an issue in Pekalongan Regency/City during flood event.

There are only 6.67% of households that depend on food produced by their own farm, which means that people are more dominant in buying food ingredients. However, there are still 2.38% of households that sell or exchange (barter) their food crops for other foods. The low diversity index of food crops (11.49%) indicates that only few people who grow food crops in Pekalongan Regency/City.

In coastal areas, 8.16% of the people become fishermen and catch fish for daily food needs (subsistence). During flood event, 100% of the respondents obtain food, either from one source (buying food, aid, or public kitchens) or various sources. This condition indicates that the need for food can be sufficiently met during a flood event.

LVI Value

Referring to Hahn (2009), the LVI value is on a scale of 0 (Not Vulnerable) to 0.50 (Very Vulnerable). The LVI value of the analyzed village/kelurahan is calculated by averaging the standardization values of the main components of LVI calculation (7 components). The standardized value of the main components itself is obtained from the average standardization value of the sub-components making up the main components (51 sub-components). A list of components and sub-components as well as the standardization values for each sub-component is presented in Appendix M.

Vulnerability	Index	Category
Socio-Economic	0,459	Very Vulnerable
Flood	0,323	Vulnerable
Water	0,444	Very Vulnerable
Food	0,261	Quite Vulnerable
Livelihood	0,497	Very Vulnerable
Disaster Relief and Management	0,357	Vulnerable
Sickness and Disease	0,485	Very Vulnerable
LVI	0,404	Very Vulnerable

The LVI value of **0.404** indicates that the assessed village/kelurahan is a **Very Vulnerable area**. Serious attention is needed for LVI with very vulnerable category, namely livelihood, sickness and disease, socio-economic and water needs. However, the **livelihood component that has the highest LVI value** should be the primary attention and focus of intervention so as not to create a chain of impact on other component and indicators.

LIVELIHOOD COMPONENT

Api-api Village and Bendan Kergon Village are two areas that have Very High vulnerability level, while 16 villages/kelurahan have High vulnerability values. Around 85.71% of respondents stated that their livelihoods were directly affected by the flood

SICKNESS AND DISEASE COMPONENT

Looking at the the vulnerability level in each assessed location shows that the level of vulnerability to sickness and disease is dominated by a High value, in which 26 villages/kelurahan are assessed as highly vulnerable

SOCIO-ECONOMIC COMPONENT

A total of 26 villages/kelurahan have a Medium vulnerability value, while 16 villages/kelurahan have a High value.

WATER NEEDS COMPONENT

The level of vulnerability in general is at the Medium level (29 villages/kelurahan) since clean water access is still adequate. However potential vulnerabilities will arise if areas that are the source or alternative sources of clean water also experience flooding, so that the supply and access of clean water is disrupted.

DISASTER RELIEF AND MANAGEMENT COMPONENT

The level of vulnerability in general is at the Medium level (33 villages/kelurahan), although there are areas with a Very High level, namely Podosugih Village and Kuripan Kertoharjo Village.

FLOOD DISASTER COMPONENT

The majority of villages/kelurahan are at Medium level of vulnerability (27 villages/kelurahan), while d 12 villages/kelurahan are classified as having a Low level

FOOD COMPONENT

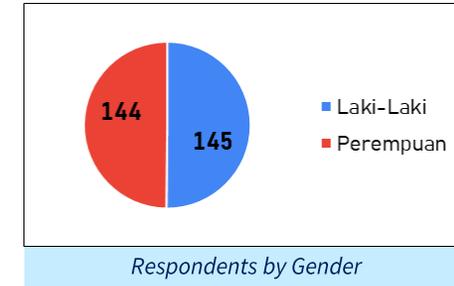
The majority of the analyzed areas have a Low vulnerability level (24 villages/kelurahan), and no village/kelurahan has a Very High or High vulnerability value

6.4 | Risk Perception Analysis

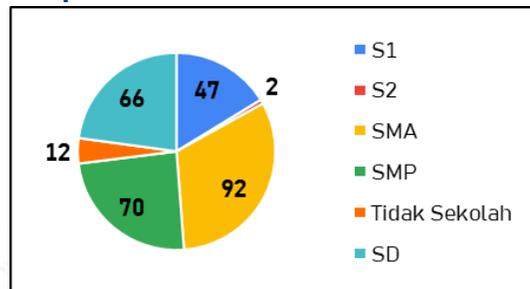
Risk Perception Analysis is used to identify the socio-economic characteristics of the community and the community's perception of flooding and flood impacts. The risk perception analysis process bases its analysis on individual intuition, personal awareness, personal experience, immeasurable losses, individual factors, and individual actions. The characteristics and perceptions towards each threat provide a response that is always different from one community to the other although it faces the same type of threat, so that the type of response of a community to a disaster risk is not linear and measurable. In this analysis, two stages of process are carried out, namely a) identification of community profiles and characteristics, and b) risk perception analysis based on village/kelurahan.

A. Identification of Profile and Characteristics

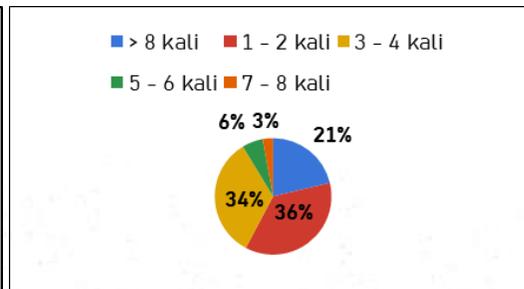
Identification was carried out on 289 respondents from 42 hotspot villages/kelurahan. The characteristics identified include the composition of gender, age, type of occupation/livelihood, education, flood experience, level of perceived impact, awareness and concerns of risks and preparedness formed.



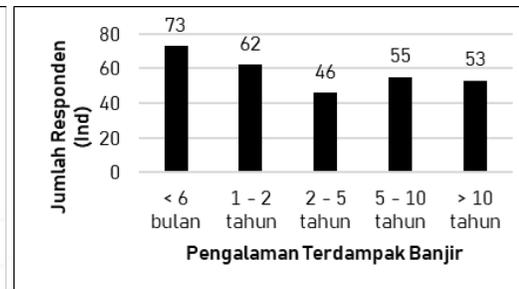
Respondent Profile and Characteristics



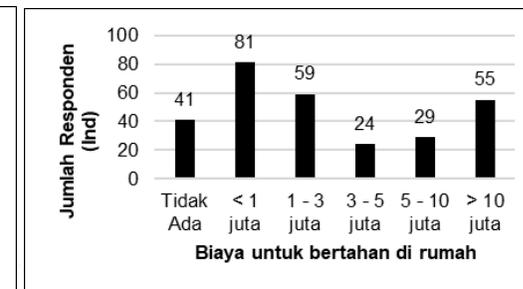
Respondents Based on Education Level



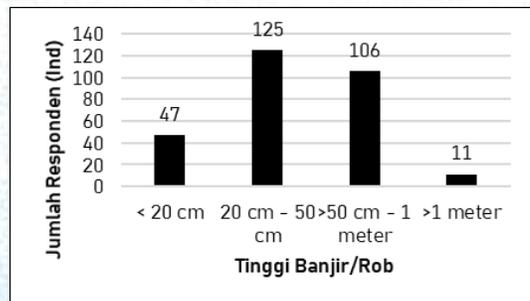
Frequency of Floods Per Year According to Respondents



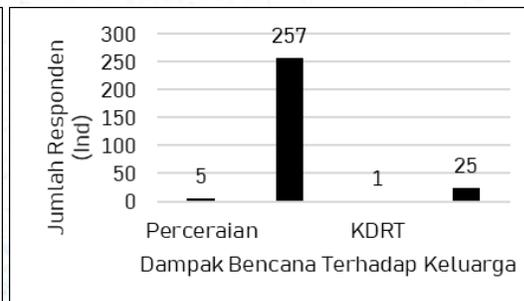
Experiences of Flood Impacts According to Respondents



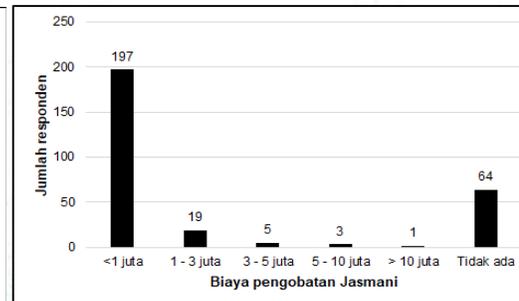
Adaptation Costs for Home Improvements According to Respondents



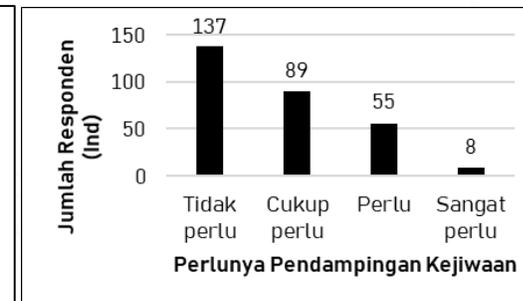
Flood Height Distribution According to Respondents



Manifestation of Psychological Impact on Gender Relations in the Family



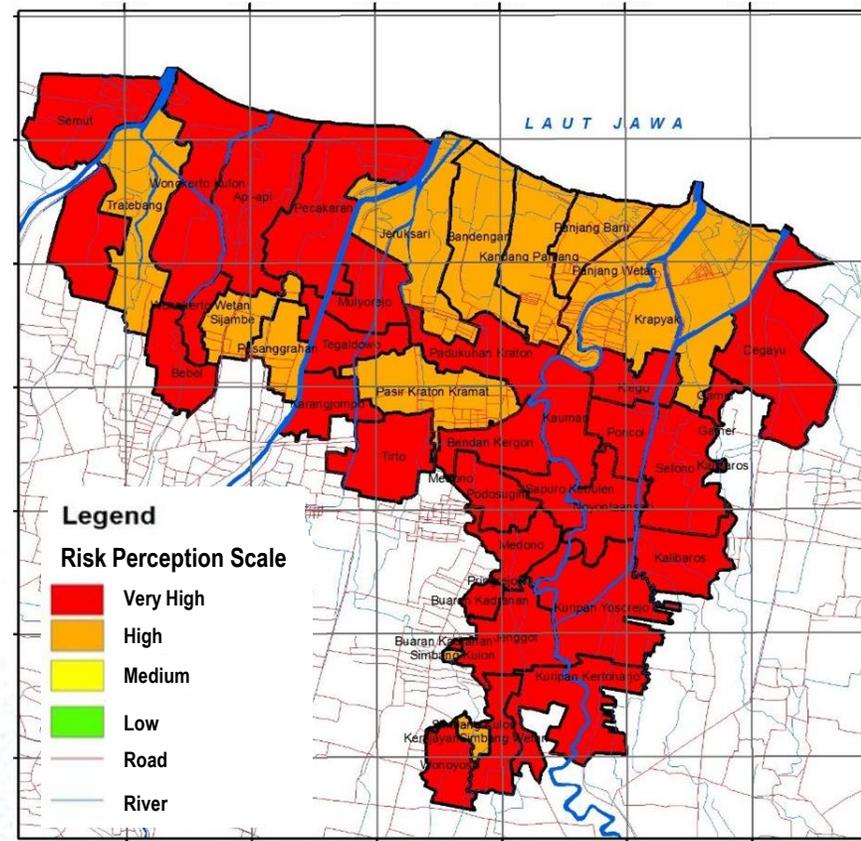
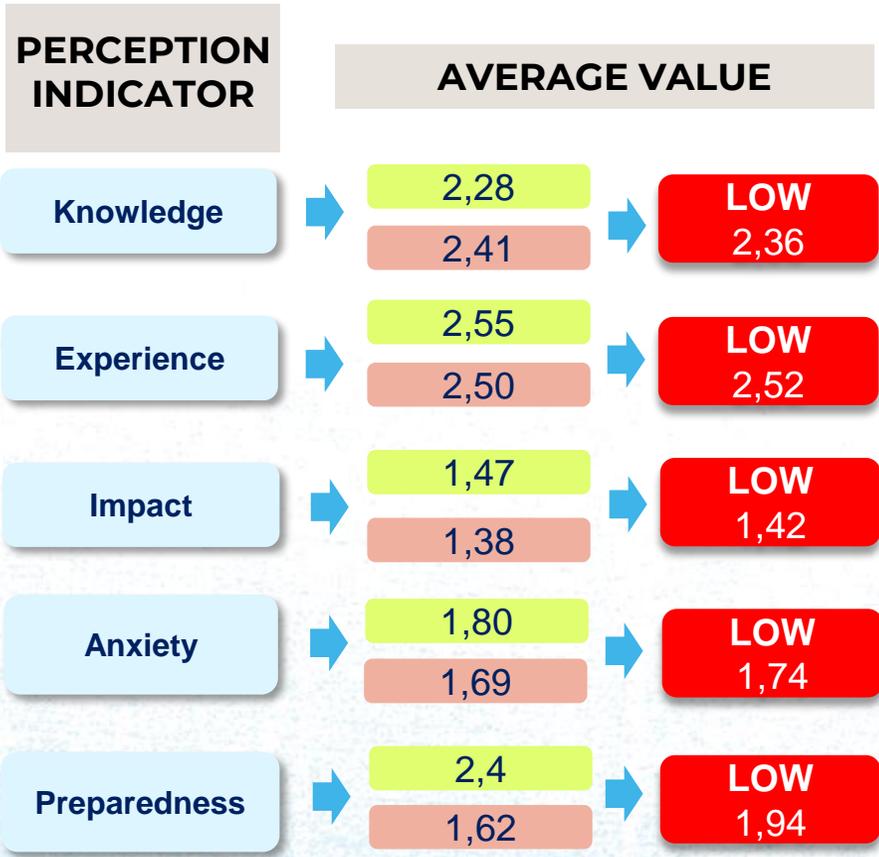
Amount of Medical Cost During Flood



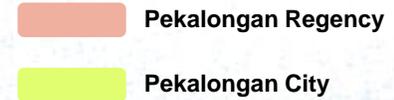
Level of Need for Psychological Assistance According to Respondents

B. Risk Perception Analysis

Risk perception analysis is carried out by taking into account the following aspects: gender culture, knowledge, direct experience, direct impact, awareness and concern, and personal preparedness. In the analysis process, gender bias has been reduced by the balance of the number of male and female respondents. Due to data limitations, the analysis carried out did not specifically examine the particular differentiating factors for culture-based risk perceptions on gender relations which were not identified in this survey, so that gender aspects were not included in the calculation of risk perceptions in this study.

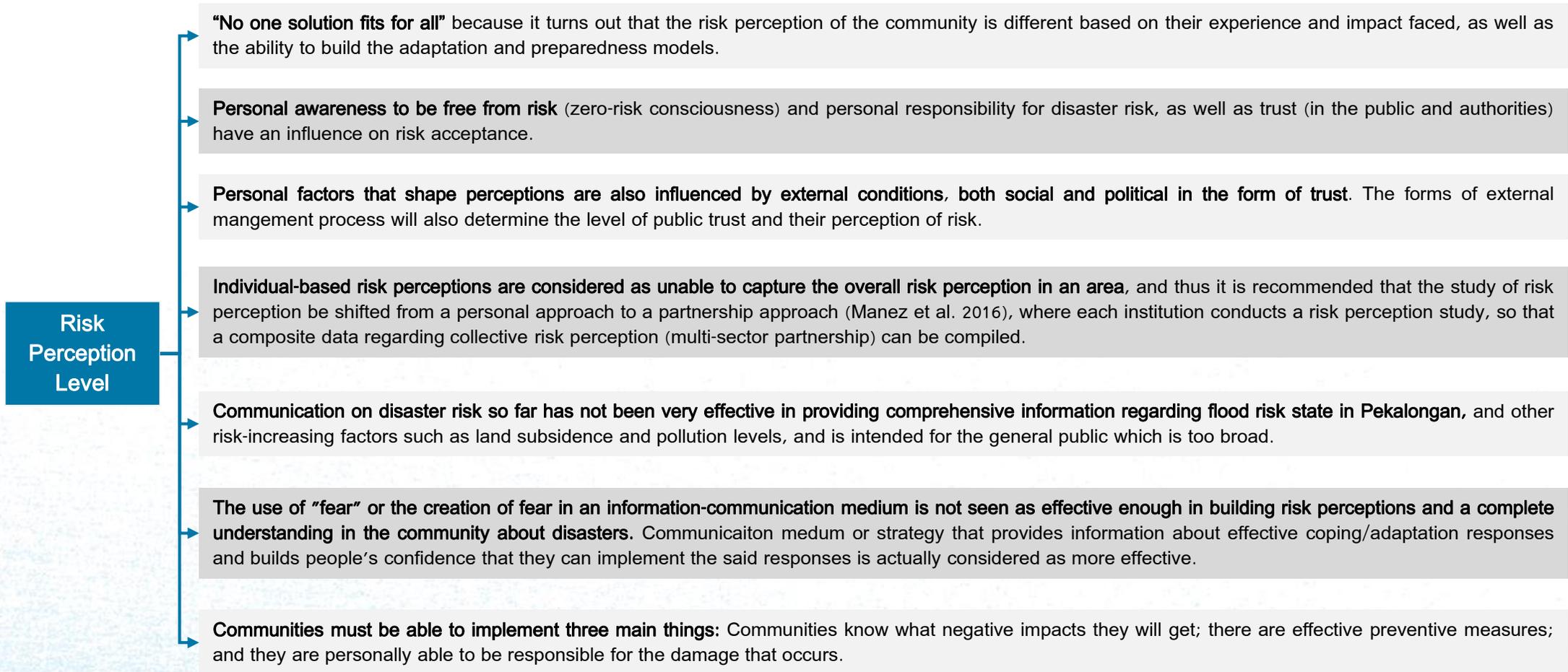


- *The diaster risk perception is assessed at a **Low level**. This value is then used as a comparison in the economic impact assessment.*
- *The process of assessing the risk perception an assessment on the threats experienced by the respondents. **The low risk perception is linear with public perception on the impact of the flood disaster***
- *In general, **no gender-based cultural barriers were identified***



Implications for Disaster Risk Reduction Policy (Communications)

The level of risk perception among Pekalongan’s flood survivors and community will certainly affect the communication strategy options for disaster risk reduction in Pekalongan Regency and Pekalongan City.



Conclusion of Disaster Risk Perception Analysis



In aggregate, in 42 study locations, the flood risk perception is at **LOW** level with a quantitative score of 9.97 (from a scale of 5-25).



There are 10 villages/kelurahan with **MEDIUM** risk perception values, namely Bandengan Village, Jeruksari Village, Kandang Panjang Village, Panjang Wetan Village, Panjang Baru Village, Pasirkraton Kramat Village, Pesanggrahan Village, Simbang Kulon Village, and Tratebang Village.



Based on administrative area, 17 villages in three sub-districts in Pekalongan Regency have a low risk perception value (10.50). Meanwhile for Pekalongan City, the low risk perception value (9.60) is identified in 25 kelurahan within four sub-districts in the area.

6.5 | Economic and Non Economic Loss Analysis

This analysis is a systematic process to assess the extent of community losses per year as a result of flood disasters in baseline conditions (2020) and projections (in 2035). The components assessed are losses due to floods experienced by the community, including material loss, non-material losses, agricultural land productivity and ecosystem services.

A. Material Loss Value

The highest material loss value is experienced by Kelurahan Pasir Kraton Kramat (Pekalongan City) and Jeruksari Village (Pekalongan Regency)

Adaptation Costs

Adaptation costs are costs that must be incurred by people affected by floods in order to remain in their affected settlement area. The largest adaptation cost value is calculated in **Pasir Kraton Kramat Village**.

Variables that affect the adaptation cost value due to flooding in an area include the number of flood events, flood height, area, type of building and the housing density.

The value of adaptation costs reaches **Rp 165,601 million**

Asset Repairment Costs

Asset repairment costs are costs incurred due to damaged assets as a result of flooding, such as to repair damaged houses, repairment of electronic devices, household appliances and other assets. The highest asset repairment costs is in **Jeruksari Village**.

The value of the asset repairment cost reaches **Rp 60,782 million**

Medical Costs

The medical cost is incurred due to the impact of flood on public health, such as diarrhea or other water-borne disease. The highest medical cost is calculate in **Kauman Village**.

The value of medical expenses reaches **Rp 15,057 million**

Additional Cost for Water

The additional cost for water is needed considering potential disruption on current and primary clean water access/source that can be caused by polluted clean water sources or cut-off of water access and distribution networks. The largest cost of clean water is in **Panjang Wetan Village**.

The additional water costs reaches **Rp 36,417 million**

Additional Cost for Food

The additional food costs are incurred to meet food needs during flood event, such as increased grocery and/or increased costs for purchasing groceries. The largest food cost is calculated in **Jeruksari Village**.

The additional food costs reaches **Rp 54,694 million**

Additional Cost for Electricity

The additional cost of electricity exists due to power outages so people will look for other sources of electrical energy such as generator sets. The largest energy costs are in **Kauman Village**.

The value of energy surcharge reaches **Rp 26,482 million**

Waste Handling Costs

The cost of handling waste is needed because of the increase in pollution or waste generation/accumulation during flood event so that there are additional costs borne by the affected communities in cleaning or handling waste. The largest waste handling costs is in **Krapyak Village**.

The value of waste handling costs reaches **Rp 146,513 million**

Decrease in Income

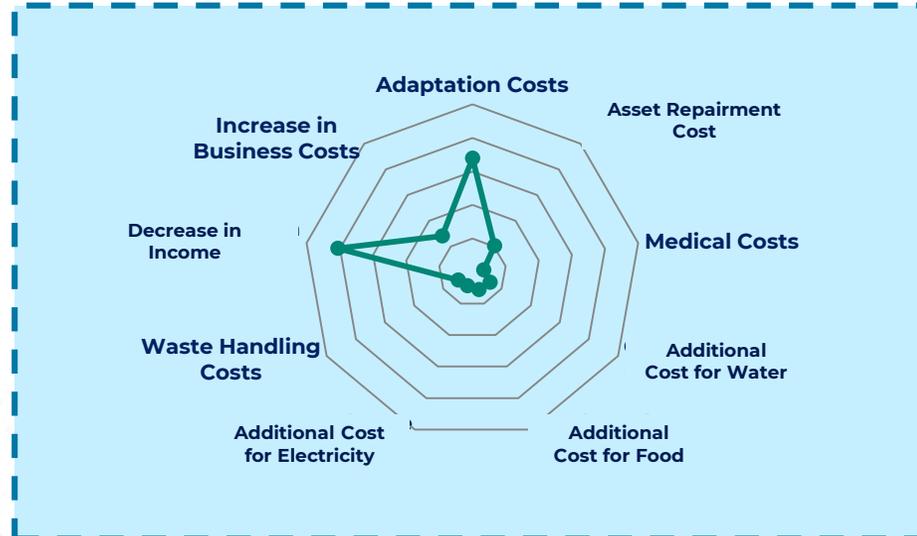
The flood had an impact on the decline in people's incomes, especially those working in the informal sector such as traders, the self-employed, labours, and also those who work in the service sector and farmers. The largest decrease in income was calculated in **Padukuhan Kraton Village**.

Overall decrease of income reaches **Rp 323,382 million**

Increase in Business Costs

The flood had an impact on increasing business costs, especially those working as traders, self-employed, working in the service sector and farmers. The largest increase in business costs is in **Padukuhan Kraton Village**.

Overall increase of business costs reaches **Rp 104,170 million**



B. Non-Material Loss Value

The highest non-material loss is experienced by Kelurahan Kauman in Pekalongan City and Bebel Village Pekalongan Regency

Psychological/Mental Disorders

The non-material loss due to psychological and mental disorders caused by flood in 25 kelurahan in Pekalongan City reaches **Rp 58,333 million**, with Pasir Kramat Kraton, Krapyak and Kandang Panjang as kelurahan with highest loss value.

The non-material loss due to psychological and mental disorders caused by flood in 17 villages within Pekalongan Regency reaches **Rp 19,032 million** with Jeruksari, Sijambe and Wonokerto Kulon as villages with the highest loss value.

Overall, the amount of psychological/mental disorders due to flooding in the 42 villages/kelurahan affected by floods reaches **Rp 77,365 million**.

Domestic Violence

The non-material loss due to domestic violence caused by flood in 25 villages of Pekalongan City reaches **Rp 241,088 million**. The kelurahan in Pekalongan City that experience the highest non-material loss from domestic violence in respective order are: Kauman, Bandengan, Degayu, Krapyak, Panjang Wetan and Pasir Kraton Kramat.

The non-material loss due to domestic violence caused by flood in 17 villages in Pekalongan Regency reaches **Rp 23,953 million**. The villages in Pekalongan Regency that experience the highest non-material loss from domestic violence in respective order are: Bebel, Jeruksari and Wonokerto Kulon.

Overall, the non-material loss value from domestic violence occurred due to flooding in the 42 villages/kelurahan affected by floods reaches **Rp 265,041 million**.

No.	The Description of Level of Psychological (Mental/Psychiatric/Stress) Disorders	Value (Rp)
a.	No need, sufficient with the fulfillment of basic needs and support of the surrounding neighbors (can be simply handled by themselves)	200,000
b.	Quite necessary, need a specific space with family or community to strengthen each other (social network)	500,000
c.	Need the help of social workers or "wise" people outside the family or neighbors in order to release stress by venting or complaining (consultation)	2,000,000
d.	Highly needed to be assisted by professional psychologists, routine therapy, even have to be placed in a special psychiatric rehabilitation room because of severe stress due to flooding (rehabilitation)	10,000,000

No.	The Description of Level of Psychological (Mental/Psychiatric/Stress) Disorders	Value (Rp)*
a.	The same sadness level for every family member	500,000
b.	Minor quarrels between family members	1,000,000
c.	Departure of one or more family members from the house	15,000,000
d.	Severe/intense fights or violence	30,000,000
e.	Injuries, serious injuries, to death	45,000,000

C. Land Productivity*

The most severe area based on loss of land productivity is in Pecakaran Village (Pekalongan Regency)

Rice Field

Each year, every rice field in average can has 2 planting seasons, with an average harvesting productivity of 5 tons / ha. The average selling price of the grain is at Rp 4,500/kg, while the average production cost per growing season is at Rp 12,000,000 /ha. Using the above average data, the average agricultural land profit per year can be calculated as reaches Rp 21,000,000 / ha, and this value is used as the productivity loss due to the loss of agricultural land as a result of flooding.

In the baseline year (2020), active rice field can only be identified in relatively small area, so that the **productivity loss for rice field at that year is at Rp.2,046 million**. Referring to the to land use projection model and also the City/Regency Spatial Plan document, there is potential for rice field land use to re-exist in the future in the area, so that loss projection might show an increasing number. |

Aquaculture Area

The affected aquaculture is generally used for the cultivation of milkfish and tilapia, either using monoculture or polyculture system. Traditional aquaculture method is often seen being applied in aquaculture land that are affected by flood. The calculation shows that the average profit of traditional aquaculture in the study area reaches Rp 13,333,333 per ha per year, and this value is used as the productivity loss due to the loss of the land (from flooding).

Overall, the loss of aquaculture productivity due to flood reaches **Rp 11,702 million**, in which all of the loss is experienced by the Pekalongan Regency. The inexistence of active aquaculture spot in the affected area (based on flood simulation model) in Pekalongan City is the reason for no productivity losses that can be calculated for Pekalongan City area.

*Calculation was only conducted to assess the baseline and future condition, without taking into account historical changes and the associated loss to the changes, so that land use change prior to 2020 was not included as the calculation component.

D. Ecosystem Services

The most severe areas related to ecosystem services are Kelurahan Panjang Wetan in Pekalongan City and Jeruksari Village in Pekalongan Regency

An ecosystem is a complex entity consisting of a dynamic community of vegetation, animals and microorganisms and their abiotic environments that interact with each other as a functional unit. Meanwhile, ecosystem services are benefits obtained by humans from ecosystems (Millennium Ecosystem Assessment, 2005). Classification of ecosystem functions and services are as follow:

- Provision: (1) Foods, (2) Clean water, (3) Fibre, fuel and other basic materials, (4) Genetic materials, (5) Medicinal and biochemical materials, and (6) Ornamental species.
- Regulatory: (7) Air quality regulation, (8) Climate regulation, (9) Prevention of disturbances, (10) Water regulation, (11) Sewage treatment, (12) Soil protection, (13) Pollination, (14) Biological arrangements, and (15) Soil formation.
- Culture: (16) Aesthetics, (17) Recreation, (18) Inspiration, (19) Heritage and cultural identity, (20) Spiritual and religious, and (21) Education.
- Supports: (22) Habitat and breeding and (23) Plasma protection.

Ecosystem Services

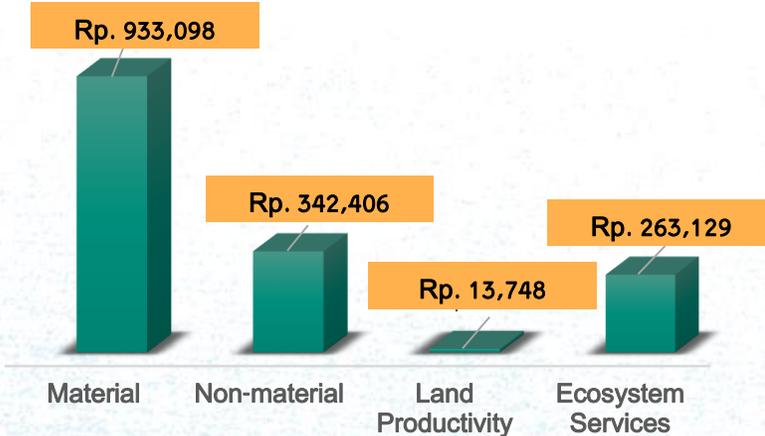
In this study, calculation on the loss of economic value of ecosystem services due to flooding is only take account of the calculation of recreational costs incurred by the affected communities.

Overall, the recreational costs of communities in the assessed 42 villages/kelurahan reaches **Rp 263,129 million**, which comprises of **Rp 35,602 million** in Pekalongan City and **Rp 227,527 million** in Pekalongan Regency.

E. Total Loss

Overall, the total economic and non-economic losses due to flooding in the study area **reaches Rp. 1.552 trillion per year (2020)**, in which Pekalongan City experiences a total loss of Rp. 1.110 trillion per year (2020), while Pekalongan Regency experiences Rp. 441 billion per year (2020).

Total Loss per Component
(in million rupiah)



F. Projection of Loss Value

Analysis of the projected value of losses due to flooding (tidal & runoff) in the study area is projected for the period of 2020 to 2035. The projection itself is conducted using the following 3 (three) scenarios:

- **Scenario 1:**

The calculation is based on the existing 2020 landuse database that is overlaid with flood simulation results in 2020, 2025, 2030 and 2035

- **Scenario 2:**

The calculation is based on the results of the projected land use changes that are overlaid with the flood simulation results in 2020, 2025, 2030 and 2035.

- **Scenario 3:**

The calculation is based on the spatial pattern in the updated Spatial Plan of Pekalongan City/Regency which is overlaid with flood simulation results in 2020, 2025, 2030 and 2035. This scenario is considered as the most relevant to be used as it used the local policy directions as the references.

Loss Value (in million rupiah)

SKENARIO	CITY/REGENCY	2020	2025	2030	2035
Scenario 1	City	209,027	5,701,352	17,780,274	23,967,832
	Regency	327,620	3,713,860	5,063,882	6,973,768
	Total	536,646	9,415,212	22,844,155	30,941,601
Scenario 2*	City	209,027	5,757,839	17,761,326	23,953,563
	Regency	327,620	3,709,095	5,011,645	6,914,586
	Total	536,646	9,466,934	22,772,971	30,868,149
Scenario 3	City	1,110,713	6,008,188	18,329,155	24,205,965
	Regency	441,668	3,735,103	5,401,560	7,077,307
	Total	1,552,381	9,743,291	23,730,715	31,283,272

* Scenario 2 is a dynamic scenario that provides the lowest loss value because this scenario includes 10 driving/contributing factors that optimistic in nature as inputs in the Landuse change projection model.

In carrying out the projection of loss calculations, there are several assumptions that are used as the basis for calculations. Here are some assumptions on which the projection is based:

1. The value of future losses is calculated based on the concept of time of value.
2. Future value calculation is done using a discount rate of 4.44% per year.
3. The discount rate value is based on the average annual inflation rate in Pekalongan City in the last 7 years (2013-2019).
4. The projected population of affected communities is calculated exponentially with the average annual population growth rate.
5. Projection of flood area distribution for each village/kelurahan area according to the projection time period.
6. The calculation of the proportion of the area in each village/kelurahan that is exposed to flooding is used as the basis for the simulation of the projected loss value.
7. The calculation of the flood distribution projection is carried out from the simulation results of GIS data.

Recapitulation of Total Economic and Non Economic Loss (in million rupiah)								
Component	Pekalongan City				Pekalongan Regency			
	2020	2025	2030	2035	2020	2025	2030	2035
Material Loss								
i. Adaptation cost	113,574	1,936,867	4,281,719	5,599,026	52,027	874,943	1,267,635	1,673,803
ii. Asset repairment cost	21,969	328,583	986,453	1,298,385	38,813	478,377	665,963	864,902
iii. Medical cost	6,192	108,114	381,877	507,878	8,865	112,529	158,730	206,948
iv. Additional cost for water needs	25,823	258,341	735,781	974,281	10,594	151,978	218,524	285,826
v. Additional cost for foods	34,621	222,712	605,593	803,269	20,073	207,695	287,036	373,575
vi. Additional cost for electricity	14,467	151,202	497,743	657,645	12,015	145,124	210,254	274,966
vii. Waste handling cost	138,142	178,739	583,718	769,626	8,371	138,142	198,275	258,434
viii. Decrease of income	318,286	879,455	1,192,268	1,600,123	5,096	96,964	147,511	191,212
ix. Increase of business cost	101,776	287,640	390,306	524,130	2,394	45,481	67,102	87,008
Total Material Loss	774,850	3,604,620	9,655,458	12,734,363	158,248	2,251,232	3,221,030	4,216,674
Non-material Loss								
i. Psychological/mental disorder	58,333	674,330	2,183,481	2,884,139	19,032	388,440	545,849	705,880
ii. Domestic violence	241,088	1,331,356	5,152,489	6,820,146	23,953	646,253	1,002,090	1,310,169
Total Non-material Loss	299,421	2,005,686	7,335,970	9,704,285	42,985	1,034,693	1,547,939	2,016,049
Decrease of Land Productivity								
i. Rice Field	840	3,232	20,402	25,346	1,206	4,657	20,366	25,301
ii. Aquaculture	0	21	5,983	7,433	11,702	15,083	16,648	20,682
Total Decrease of Land Productivity	840	3,253	26,385	32,779	12,908	19,740	37,014	45,983
Ecosystem Services (Tourism)	35,602	394,629	1,311,342	1,734,538	227,527	429,438	595,577	798,601
TOTAL	1,110,713	6,008,188	18,329,155	24,205,965	441,668	3,735,103	5,401,560	7,077,307

Calculation shows that the total loss due to flooding in 2020 (baseline) reaches approximately Rp. 1.552 trillion per year, Pekalongan City experiences a total loss of IDR 1.110 trillion per year (2020), while Pekalongan Regency experiences Rp.441 billion per year. Using scenario for the projection, the projected total economic and non-economic loss for the area is as follow:

- Around Rp. 9.74 trillion in 2025, in which Pekalongan City will experience Rp. 6.008 trillion of total loss, while Pekalongan Regency Rp. 3.735 trillion of total loss. A significantly higher loss that can be faced by the Pekalongan City shows that the area potentially facing higher magnitude of loss compared to the Pekalongan Regency.
- Around Rp. 23.73 trillion in 2030, in which Pekalongan City will experience Rp. 18.3 trillion of total loss, while Pekalongan Regency Rp. 5.4 trillion of total loss.
- Around Rp. 31.28 trillion in 2035, in which Pekalongan City will experience Rp. 24.2 trillion of total loss, while Pekalongan Regency Rp. 7 trillion of total loss.

The following components are calculated as experiencing the highest loss value: i) economic loss, namely adaptation cost and asset repairment cost; and non-economic loss, namely: psychological disorder and domestic violence. Analysis further shows that livelihood is the sector that most affected by flooding event since the operations and continuation of this sector are related to several cost components, including: adaptation cost, asset repairment cost, additional cost (for water and electricity), waste handling cost, decrease of income and increase of business cost; not to mention loss of land productivity for land-based livelihood.

Conclusion of Economic and Non Economic Loss Analysis



The total economic and non-economic loss due to flooding in the study area in 2020 reaches Rp 1.552 trillion per year, which comprise of Rp 1.110 trillion per year in Pekalongan City area and Rp 441 billion per year in Pekalongan Regency area.

- ✓ The material loss reaches Rp 933.098 billion per year.
- ✓ The non-material loss amounted to Rp 342.406 billion per year.
- ✓ The land productivity loss amounted to Rp 13.748 billion per year.
- ✓ The ecosystem service loss amounted to Rp 263.129 billion per year.

SCENARIO 1 (Using the Existing Landuse in 2020 as the basis)

The projected value of flood loss in 2035 reaches Rp. 30.94 trillion, which consists of the Pekalongan City area of Rp. 23.97 trillion and Pekalongan Regency of Rp. 6.97 trillion.

SCENARIO 2 (Using Landuse Change Projection as the basis)

The projected value of flood loss in 2035 reached 30.87 trillion rupiah, which consists of the Pekalongan City area of Rp. 23.9 trillion and Pekalongan Regency of Rp. 6.9 trillion.

SCENARIO 3 (Using Spatial Pattern in the Spatial Plan as the basis)

The projected value of flood losses in 2035 reached 31.28 trillion rupiah, which consists of the Pekalongan City area of Rp. 24.2 trillion and Pekalongan Regency of Rp. 7 trillion.

6.6 | Implications of Economic and Non-Economic Losses on Policy

Considering the dynamics of flood issues in the area and the causative factors, flood management in Pekalongan should be mainstreamed to almost all development sectors, with an integrative management strategy/actions (cannot be done in partial manner). The increasing urgency also calls for an acceleration strategy, especially when the limited fiscal capacity and resources availability of the local government are taken into account. Policy and authority then became critical entry points to provide inputs and recommendations needed by the local government to support the acceleration. Having conducted the Climate Risks and Impact Assessment (CRIA), the ZFRA proposed the following flood management framework which divides the strategy into four clusters.

Matrix of Clusters of Strategy, Common Thread and Policy Implications (Indicative)

NO.	CLUSTER	COMMON THREAD IDENTIFICATION	RELATED SECTORS
1.	Regional Adaptation (Separation of Wet and Dry Zones)	<p>a. Regional Adaptation</p> <p>a.1. Strengthening Spatial Plan through detailed spatial plan by considering flood risk and land subsidence map, and also formulation of permit schemes (for construction) along with the relevant incentives and disincentives scheme.</p> <p>a.2. Formulation of land rights fulfillment scheme (Land Consolidation and Relocation)</p> <p>b. Regional Adaptation through the formulation of a resilient (and adaptive) livelihood strategy</p>	<ul style="list-style-type: none"> Spatial Planning and Land Regional Development Planning Public Works and Public Housing Environment Cooperative and Trade Industry Fisheries Agriculture River Management Marine and Fisheries Spatial Planning and Land Public Works Environment
2.	Infrastructure-based Flood Control	<p>a. Hard Infrastructure</p> <p>a.1. Development of blue green corridors or infrastructure in the midstream and downstream segments of Pekalongan</p> <p>a.2. Utilization of seawall by taking into account other potential disaster (land subsidence, sedimentation, coastal dynamics, new inundation, etc.)</p> <p>a.3. Improving the quality of the Kupang watershed drainage system by considering the climate risks and the impacts</p> <p>a.4. Development of flood early warning system for Kupang Watershed based on climate variable threshold</p> <p>a.5. The use of renewable energy for the operationalization of physical infrastructure</p> <p>b. Soft Infrastructure</p> <p>b.1. Inclusion of community acceptance as the considering factors in a Feasibility study process for an infrastructure</p> <p>b.2. Assessment of the potential and feasibility of utilizing renewable energy for infrastructure operationalization</p> <p>b.3. Low-cost and environmentally friendly infrastructure design</p> <p>b.4. Development of contingency plans in high-risk areas in sub-district scale</p>	<ul style="list-style-type: none"> Public Works and Public Housing Environment District Sub District Landscaping and Waste Management Meteorological and Climatological Disaster Management Energy and Mineral Resources Sub-district Village/kelurahan
3.	Water Resource Management through Water Resources Infrastructure and Conservation	<p>a. Strengthening the Structure of the River Region (WS)</p> <p>a.1. Improving the reliability of the Petanglong Regional Water Supply System by developing a reservoir that will serve as a water source for the Water Supply System</p> <p>a.2. Strengthening integrated estuary system (optimization of long storage)</p> <p>a.3. River normalization and aso sedimentation and erosion control</p> <p>a.4. Development of contingency plans that includes the functions of the infrastructure</p> <p>b. Watershed Rehabilitation and Conservation</p> <p>b.1. Conservation of upstream areas and critical land (Petungkriyono, Talun, dan Wonotunggal)</p> <p>b.2. Conservation and rehabilitation of the midstream segment of the watershed (Karangdadap, Kedungwuni dan Warungasem)</p> <p>b.3. Conservation and rehabilitation of downstream and coastal segments of watersheds</p>	<ul style="list-style-type: none"> River Management Spatial Planning and Land Clean Water Management Public Works Marine Environment
4.	Strengthening Human Resources and Institutional Capacity in Disaster Risk Reduction	<p>a. Cultural Transformation through comprehensive communication of disasters and risks.</p> <p>b. Community involvement in disaster risk reduction efforts</p> <p>c. Increased capacity of the community in utilizing early warning systems</p> <p>d. Control and Supervision of the river riparian, lakes, reservoirs and springs together with all relevant agencies and communities</p> <p>e. Strengthening institutional capacity in reducing disaster risk (for BPBD) and development of Local Action Plan for Disaster Management</p>	<ul style="list-style-type: none"> Informatics Disaster Management Education River Management Marine and Coast Sub District Village/kelurahan Clean Water Management Security and Order

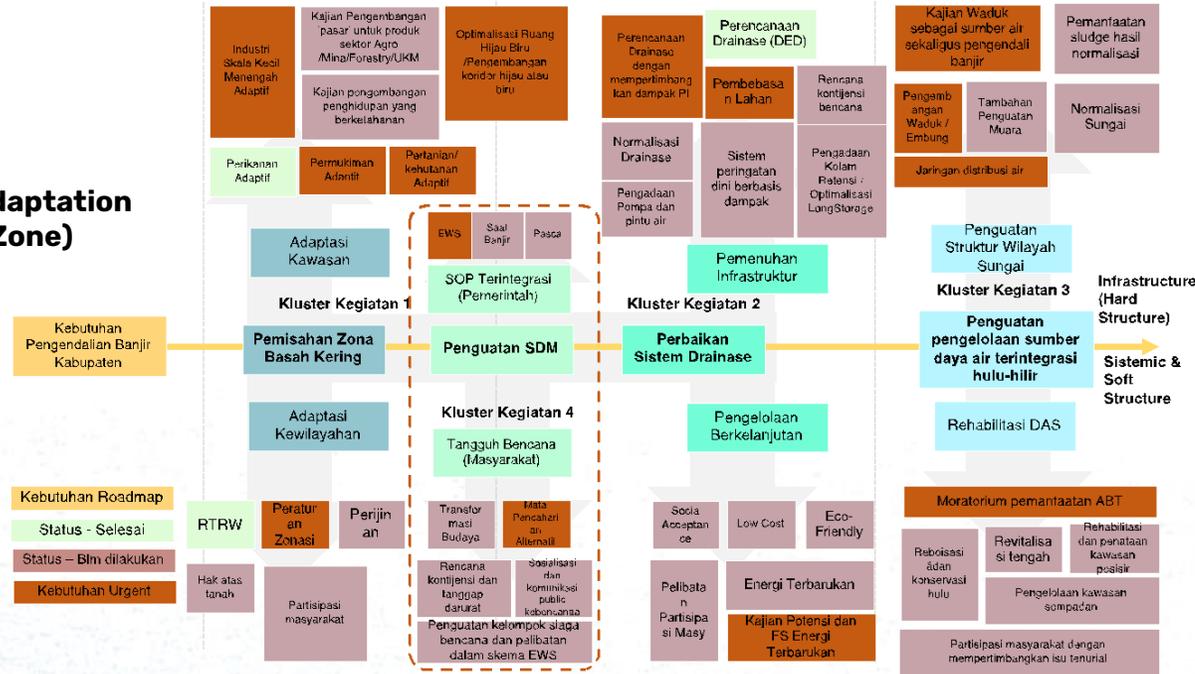
Indicatives for the Development of Policy (Strategy) Clusters for Flood Risk Reduction in Pekalongan

The proposed frameworks put emphasis on multi-scale approach in flood management, from macro scale (in this case the spatial planning and licensing sector), meso scale (in the form of water management infrastructure), and down to the micro scale such as strengthening human resources (including the community) and also fostering adaptive governance with regards (but not limited) to the ever increasing flood risks.

CLUSTER 1

Area & Regional Adaptation (Separation of Wet and Dry Zone)

This policy cluster emphasizing scenarios that should be considered when dealing with frequent flooding with intensity that continually increase. Spatial development is a strategy that needs to be considered (across sectors and across regions) when talking about the future of the region and the risks that potentially faced by them. In the context of space, the adaptation strategy can also be carried out simultaneously with Cluster 4 regarding the strengthening of human resources.



CLUSTER 4

Strengthening Human Resources and Institutional Capacity in Disaster Risk Reduction

Humans and institutions are inseparable factors in the water resource management. No matter how strong the physical structure that is built, its function will be weak if it is not supported by proficient human resources and also a solid institutional framework for its operations and maintenance. Taking into account these conditions, this cluster is focused on increasing the community's capacity to strengthen the institutional framework in addressing flood risk.

CLUSTER 2

Infrastructure-based Flood Control

CRIA of the Kupang watershed shows the potential for increased risk of flooding (flash flood and tidal flood). The flood modelling further shows that the inundation could spatially expanding towards the east coast and also the middle and south (moving towards midstream) of the Kupang watershed; characterized by changes in the area and height of the flood inundation. Some areas that have the potential to experience a significant increase in height and total inundated area include village/kelurahan: Tirta, Pasir Kraton, Padukuhan Kraton, Karang Jompo, Tegaldowo, Bebel, Pesanggarahan, Sijambe and Wonokerto Wetan.

CLUSTER 3

Water Resources Management Infrastructure and Conservation

This Cluster views that the root cause of flooding is poor water management from upstream to downstream, therefore a holistic approach is needed to restore water absorption functions and optimize water sources for the needs of Pekalongan community. Within this cluster, efforts to manage water resources are not only focusing on handling the affected area which is reactive and short-term in nature, but primarily proactive in regulating the flow of an integrated hydrological system in the area, which means the working area is broader than merely the directly affected area.

Appendix A Hazard Analysis Data Input

Appendix B Modeling of 2026-2030 Inundation for Decadal Prediction (left) and RCP 4.5 Projection (right)

Appendix C Flood Hazard Level Index per Village in Pekalongan Regency for Decadal Prediction (left) and RCP 4.5 Projection (right)

Appendix D Flood Hazard Level Index per Kelurahan in Pekalongan City for Decadal Prediction (left) and RCP 4.5 Projection (right)

Appendix E Sensitivity Components and Indicators

Appendix F Exposure Components and Indicators

Appendix G Adaptive Capacity Components and Indicators

Appendix H Land Use Change Projection Indicators

Appendix I Land Use Change Trend by 2020-2035

Appendix J Decadal Prediction Flood Risk Projection (2025-2035)

Appendix K RCP 4.5 Scenario Flood Risk Projection (2025-2035)

Appendix L Number of Villages/Kelurahans in Study Location per Risk Level

Appendix M Livelihood Vulnerability Index Component and Sub-Component

APPENDIX A

Hazard Analysis Data Input

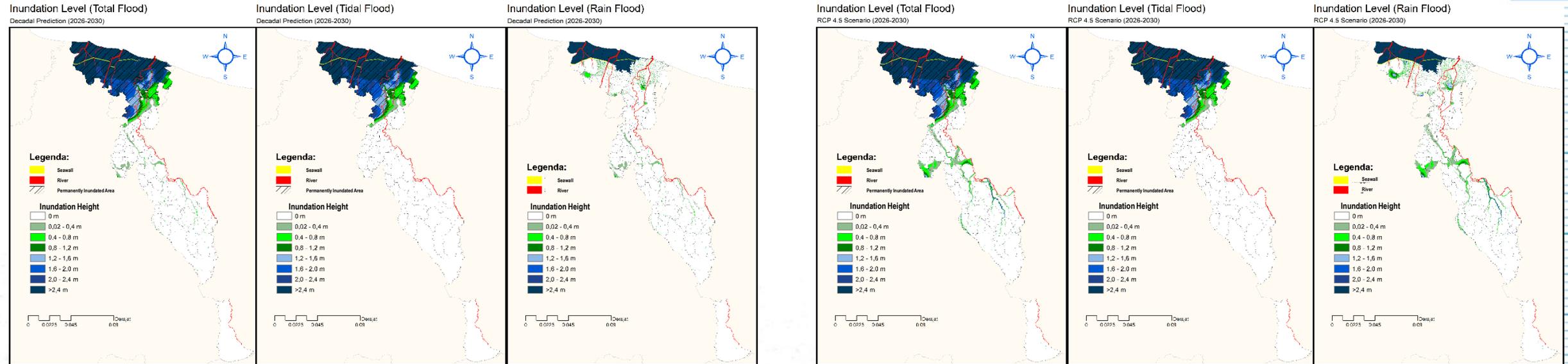
NO	DATA	SOURCE	TYPE OF DATA
Flood Model			
1	DTM (20 x 20 m is resampled to 30 x 30 m)	CoREM	Spatial
2	- Land Cover Map - Land Use Map	CoREM	
3	SHP of Kupang Watershed	BPDAS of Pekalongan	
4	Meteorological Data: - Rainfall (RF/CF)	Pusdataru of Pekalongan City, BMKG, CHIRPS (Funk et al., 2015), POWER NASA/ECMWF	Tabular
5	Land Parameter and Soil Parameter	Bibliography	
6	Land subsidence rate	CoREM	
7	- Tidal Elevation - Long Term Mean Sea Level - Annual Mean Sea Level Projection	CoREM, Copernicus BIG	
8	Daily Tide	CoREM	
9	Flood Event Data (Spatial, spot, and temporal)	City BPBD, field survey	
Climate Projection Simulation			
10	Global Climate Model	https://climexp.knmi.nl/selectfield_cmip5.cgi?id=someone@somewhere	Spatial
11	Regional Climate Model (RegCM)	Faqih et al. (2016), TNC Indonesia (2017), BIG	
12	CHIRPS: Rainfall Estimates from Rain Gauge and Satellite Observations	CHIRP data that have been corrected with observation data (1981-2019)	

GCM CMIPS Model

MODEL'S NAME	INSTITUTION	SPATIAL RESOLUTION	REFEREN CES
ACCESS1.0	Australian Community Climate and Earth System Simulator coupled model (ACCESS-CM)	1,25°×1,875°	(Bi et al. 2013)
CanESM2	Canadian Centre for Climate Modelling and Analysis (CCCma), Canada	2,8°×2,8°	Chylek et al. 2011
CMCC-CM	Centro Euro-Mediterraneo per i Cambiamenti Climatici (CMCC), Italy	0,75°×0,75°	Scoccimarro et al. 2011
CMCC-CMS	Centro Euro-Mediterraneo per i Cambiamenti Climatici (CMCC), Italy	1,875°×1,875°	Scoccimarro et al. 2011
CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia	1,875°×1,875°	Jeffrey et al. 2013
FGOALS-s2	State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), China	2,8°×1,4°	Qing et al. 2013
GFDL-ESM2G	Geophysical Fluid Dynamics Laboratory (GFDL), USA	2,5°×2,0°	Dunne et al. 2013
HadGEM2-ES	Met Office Hadley Centre, UK	1,875°×1,25°	(Martin et al. 2011)
IPSL-CM5B-LR	L'Institut Pierre-Simon Laplace (IPSL), France	3,75°×1,875°	Dufresne et al. 2013
MIROC5	Model for Interdisciplinary Research on Climate (MIROC), Japan	1,4°×1,4°	(Tatebe et al. 2012)
MIROC-ESM-CHEM	Model for Interdisciplinary Research on Climate (MIROC), Japan	2,8125°×2,8125°	Watanabe et al. 2011
MPI-ESM-LR	Max Planck Institute, Germany	1,875°×1,875°	Block dan Mauritsen 2013

APPENDIX B

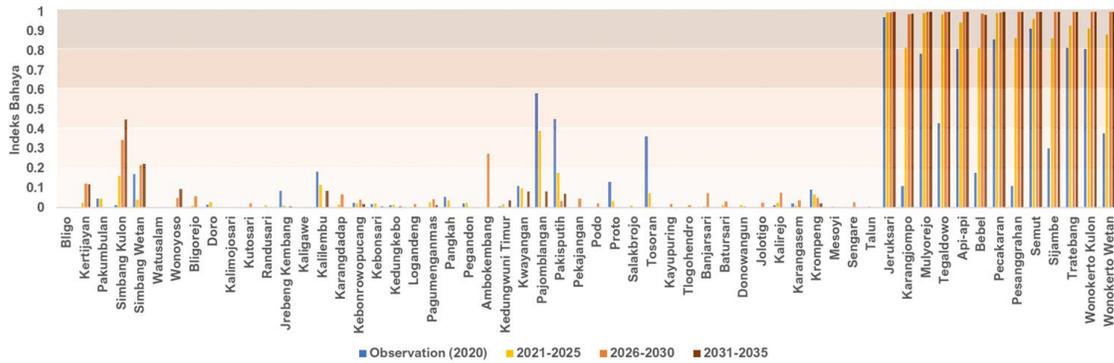
Modeling of 2026-2030 Inundation for Decadal Prediction (left) and RCP 4.5 Projection (right)



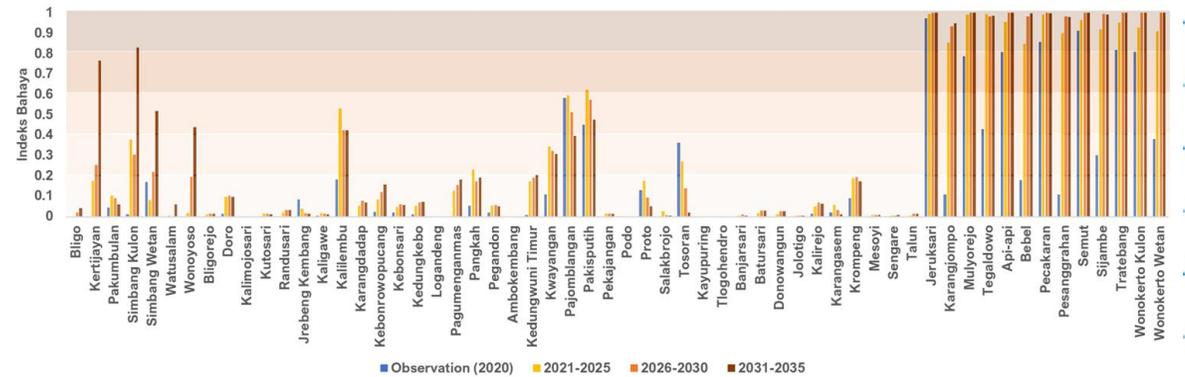
APPENDIX C

Flood Hazard Level Index by Village in Pekalongan Regency for Decadal Prediction (left) and RCP 4.5 Projection (right)

Pekalongan Regency (Decadal Prediction)



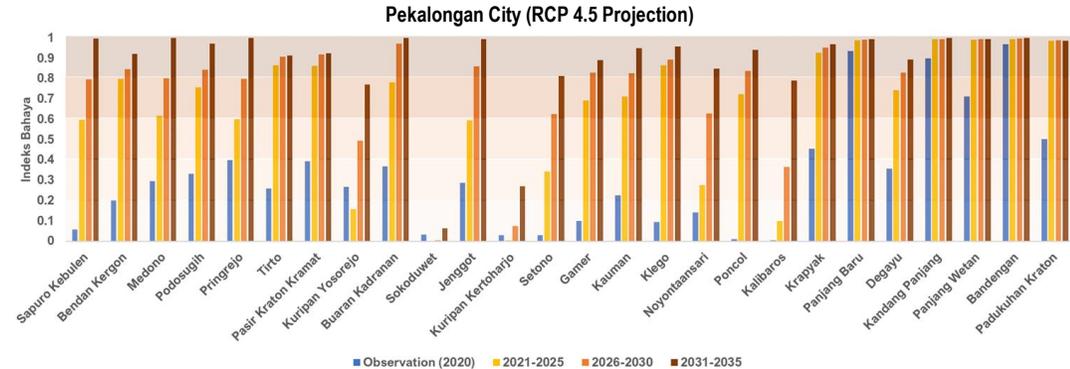
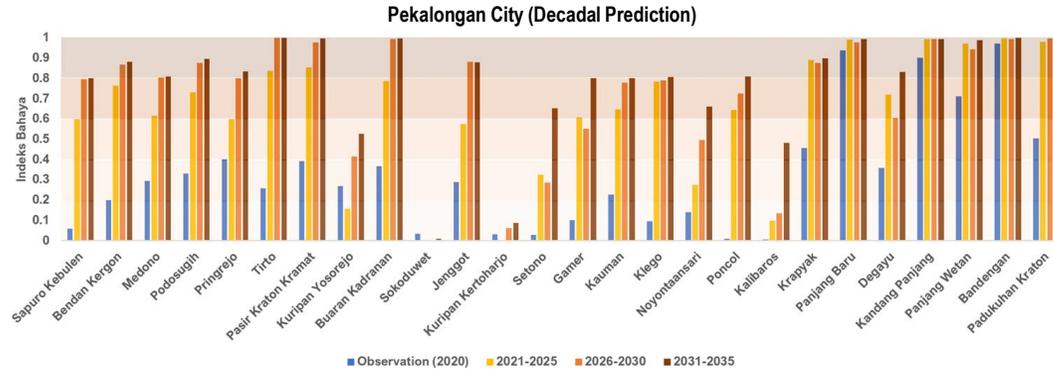
Pekalongan Regency (RCP 4.5 Projection)



Pekalongan Regency								
Hazard Level	Observation	Decadal			Observation	Scenario (RCP4.5)		
	2015-2019	2021-2025	2026-2030	2031-2035	2015-2019	2021-2025	2026-2030	2031-2035
Not affected	17	4	11	21	17	4	3	4
Very Low	28	40	31	22	28	34	35	32
Low	3	1	3	1	3	4	4	3
Moderate	3	0	0	1	3	2	3	4
High	1	0	0	0	1	1	0	1
Very High	6	13	13	13	6	13	13	14

APPENDIX D

Flood Hazard Level Index by *Kelurahan* in Pekalongan City for Decadal Prediction (left) and RCP 4.5 Projection (right)



Hazard Level	Pekalongan City							
	Observation	Decadal			Observation	Scenario (RCP4.5)		
	2015-2019	2021-2025	2026-2030	2031-2035	2015-2019	2021-2025	2026-2030	2031-2035
Not affected	0	1	1	0	0	0	0	0
Very Low	10	3	2	2	10	4	2	1
Low	9	2	1	0	9	2	1	1
Moderate	3	2	3	2	3	2	1	0
High	1	10	5	4	1	9	3	2
Very High	3	8	14	18	3	9	19	22

Appendix E

Sensitivity Components and Indicators (1)

NO	COMPONENT	INDICATOR	DESCRIPTION
1	Infrastructure and Settlement (K1)	Percent of houses unable to endure disaster by village	Non-permanent buildings with lower capacity to endure the impacts from climate variability and extreme climate such as flood and tidal flood
2	Spatial Planning (K2)	Percentage of green area size by village	The wider the green area is, the wider the water absorption area will be, thus making the kelurahan/village have low sensitivity towards flood/tidal flood
3	Poverty (K3)	Ratio of poor population	Poor population with low financial capacity will suffer the highest impacts from climate variability and extreme climate such as flood/tidal flood, and need more time to achieve recovery
4	Vulnerable Group (K4)	<ul style="list-style-type: none"> • Ratio of number of female population (Gender) • Ratio of number of elderly population (>60 years-old) • Ratio of number of child population (>12 years-old) • Ratio of number of people with disability 	Vulnerable population with lower resilience and ability to overcome flood/tidal flood
5	Per Capita (K5) Income	Percentage of households which members work as a farmer, fish pponder, or fisher to total livelihood by village	The lower the population's income in a kelurahan/village, the more significant the impacts of flood/tidal flood they will suffer

Sensitivity Components and Indicators (2)

NO	COMPONENT	INDICATOR	DESCRIPTION
6	Land Ownership (K6)	Percentage of number of households without land legality (ownership) by village (%)	The higher the percentage of households without land legality (ownership) in a <i>kelurahan</i> /village is, the higher the sensitivity value of that <i>kelurahan</i> /village will be
7	Health (K7)	Number of incidents of water-borne disease by district.	Climate variability and extreme climate will influence the frequency and intensity of flood/tidal flood events that lead to the increasing number of water-borne disease incidents in the area
8	Critical Asset (K8)	The number of critical/vital assets/facilities damaged/affected by flood and tidal flood (health, infrastructure, market, energy, transport, etc.).	The more critical assets are damaged due to flood impacts, the higher the burden will be for the community and local government to mitigate and recover the disaster impacts in the <i>kelurahan</i> /village.
9	GRDP of Affected Sector (K9)	Percentage of GRDP contribution per affected sector (fish pond and ricefield) per district.	The more sectors are affected by flood/tidal flood, the higher the sensitivity index will be
10	Infrastructure, Facility and Utility (K10)	Classes of road (transport) that are frequently affected.	The more frequent transport facilities are affected, the higher disturbance to transportation flow, which will lead to numerous other aspects

Appendix F

Exposure Components and Indicators (1)

NO	COMPONENT	INDICATOR	DESCRIPTION
1	Topography (K1)	<ul style="list-style-type: none"> Inclination Land Morphology Elevation 	Areas with low inclination, flat land morphology and low elevation have relatively higher exposure to flood and tidal flood
2	Geomorphology (K2)	Alluvial Plain	The <i>kelurahans/villages</i> which most areas are located in alluvial plain have higher exposure level
3	Beach Erosion / Sedimentation (K3)	Beach erosion area	The eroded beach will experience higher erosion level caused by extreme climate, which might lead to stronger sea wave and current and increase the erosion rate in that area
4	Land Use (K4)	<ul style="list-style-type: none"> Proportion of productive land use (%) Type of dominant land use by village 	The <i>kelurahans/villages</i> which productive and dominant land use productive are predominantly settlement and industry have a relatively high level of exposure
5	Infrastructure and Settlement (K5)	Proportion of area size experiencing land subsidence by village (%)	The areas experiencing land subsidence will increase the potential inundation from flood and tidal flood in that area.

Exposure Components and Indicators (2)

NO	COMPONENT	INDICATOR	DESCRIPTION
6	Distance from Disaster Source (K6)	Distance from river and canal that potentially cause flood and tidal flood	The closer an area from river and beach is, the higher its potential exposure to flood will be, since the area is closer to the disaster source
7	Demography (K7)	Population density by village	<i>Kelurahans</i> /villages having more dense population will have more population exposed to climate-related disaster, which will lead to flood and tidal flood
8	Spatial Planning (K8)	The size of settlement area that are located along river bank/coast (%)	Settlements in such locations have higher exposure value as they are located in areas with potential flood and tidal flood, which reduce the protection function of green area

Appendix G

Adaptive Capacity Components and Indicators (1)

NO	COMPONENT	INDICATOR	DESCRIPTION
1	Regulation and Planning	<ul style="list-style-type: none"> Regulatory support from spatial planning aspect Mitigation of flood and tidal flood in RPJM (Mid-Term Development Plan) 	Adaptive capacity is strongly determined by spatial policy directives on disaster, and disaster mitigation program in the RPJM (Mid-Term Development Plan)
2	Disaster Financing	<ul style="list-style-type: none"> Local financing support for flood and tidal flood mitigation Existence of early warning system for flood Existence of early warning system for tidal flood 	The more economic sources is available, the higher the adaptive capacity in a particular area
3	Disaster Early Warning	<ul style="list-style-type: none"> Existence of early warning system for flood Existence of early warning system for tidal flood 	Disaster early warning system is critical, since adequate adaptive capacity can accelerate community's action
4	Organization in form of Disaster Service Center	<ul style="list-style-type: none"> Tidal-related disaster information center Quality of government's service in tidal flood preparedness 	It can be shown through the relevant institution or agency's capacity in conducting adaptive measures toward floods which frequently occur in certain areas.
5	Institution in form of Community Group (PokMas)	<ul style="list-style-type: none"> Existence of disaster resilient community (Masyarakat Tangguh Bencana) The background of the community group establishment are: 	Through government facilities, the community group can become the parameter of disaster resilience, since factors supporting disaster resilience action and initiative might trigger short and long-term changes

Adaptive Capacity Components and Indicators (2)

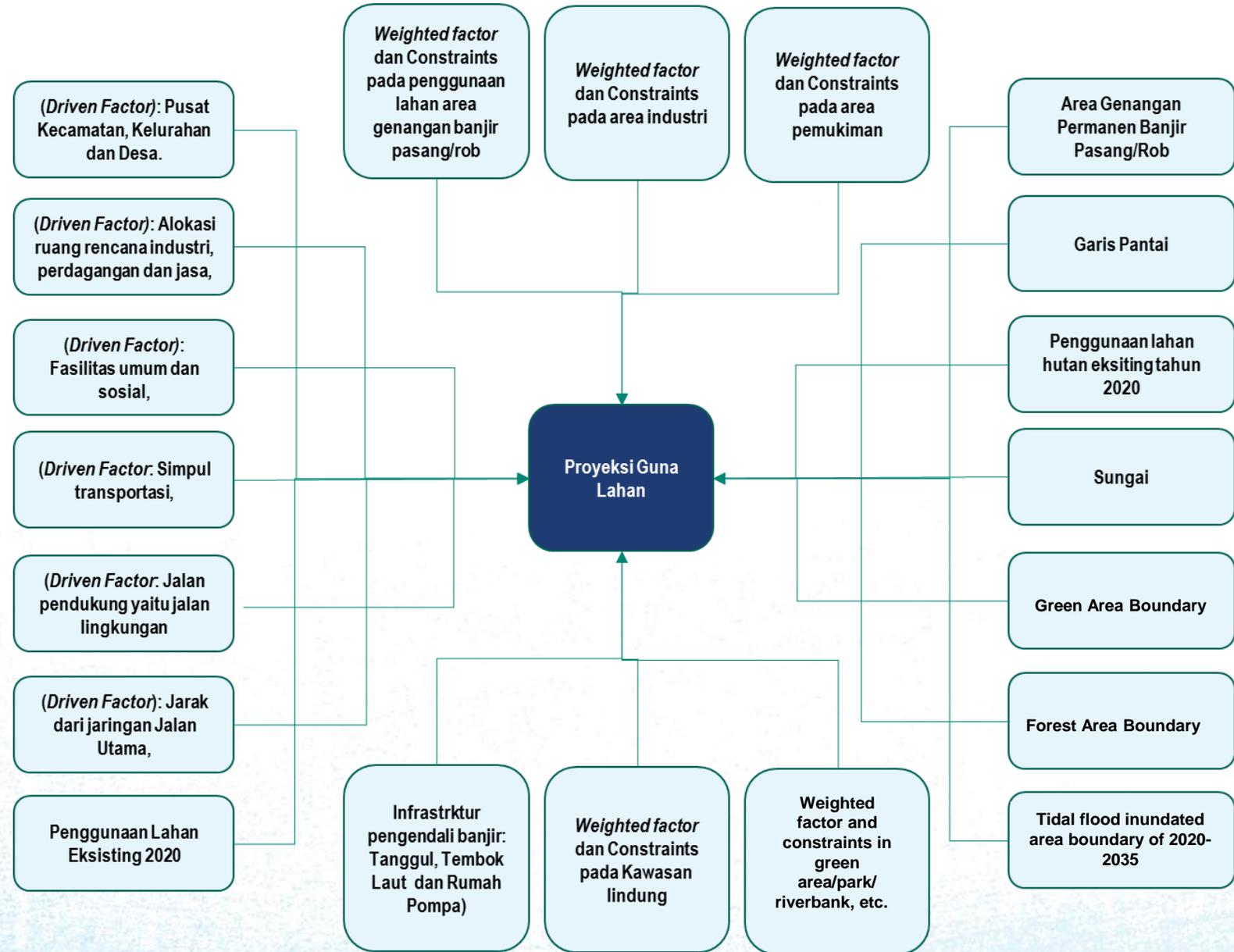
NO	COMPONENT	INDICATOR	DESCRIPTION
6	Disaster Program	<ul style="list-style-type: none"> Existence of disaster mitigation program Existence of conservation/rehabilitation program to overcome flood and tidal flood 	Existence of a disaster program might increase the adaptive capacity of a city and or an area
7	Education, Counseling, and Knowledge for Community	<ul style="list-style-type: none"> Ratio of higher education Counseling and assistance on tidal flood 	Adaptive capacity highly depends on trainings and information on disaster
8	Disaster Mitigation	<ul style="list-style-type: none"> Disaster plan document at village scale Local Action Plan for DDR (RAD PRB) implementation document 	Disaster-related planning document and a systematized implementation action are one of the marks of adequate capacity to address tidal flood
9	Preparedness and Contingency	<ul style="list-style-type: none"> Preparedness plan and steps to mitigate flood Existence of SOP for disaster emergency (contingency) Speed of emergency response (contingency) implementation, planning and steps of preparedness in mitigating tidal flood 	Tactical ability of a government institution to address a disaster in emergency situation reflects its adaptive capacity in mitigating flood and tidal flood
10	Infrastructure for Flood and Tidal Flood Control	Existence of polder, retention pool, sea wall, etc.	Existence of infrastructures related to flood and tidal flood control will increase the adaptive capacity

Adaptive Capacity Components and Indicators (3)

NO	COMPONENT	INDICATOR	DESCRIPTION
11	Community's Perception toward Flood and Tidal Flood (Programs)	Community's direct perception (response/acceptance) to flood and tidal flood mitigation programs	Community's perception toward tidal flood program might influence the community's resilience
12	Local Wisdom	Local wisdom associated with flood and tidal flood	Community's creativity (local wisdom) can affect the adaptive capacity in an area
13	Well-being	Percentage of prosperous family	The percentage of prosperous family shows the volatility level of a community in facing shocks and stresses caused by flood and tidal flood disasters
14	Infrastructure, Facility and Utility	<ul style="list-style-type: none"> • Availability of education supporting facilities and infrastructures • Percentage of household in main fuel used to cook by village (%) • Limited clean water source facility. (percentage of number of family not using pipe water (PAM/PDAM)) 	Existence of social and general life supporting facilities and infrastructures are the factors that preserve the sustainability of life and resilience of a disaster-affected community
15	Poor Family Health Insurance	Proportion of poor community having the KIS (Healthy Indonesian Card)/BPJS Card	Limited health insurance available for poor family might decrease the adaptive capacity of a community group due to the lower life expectancy it causes.

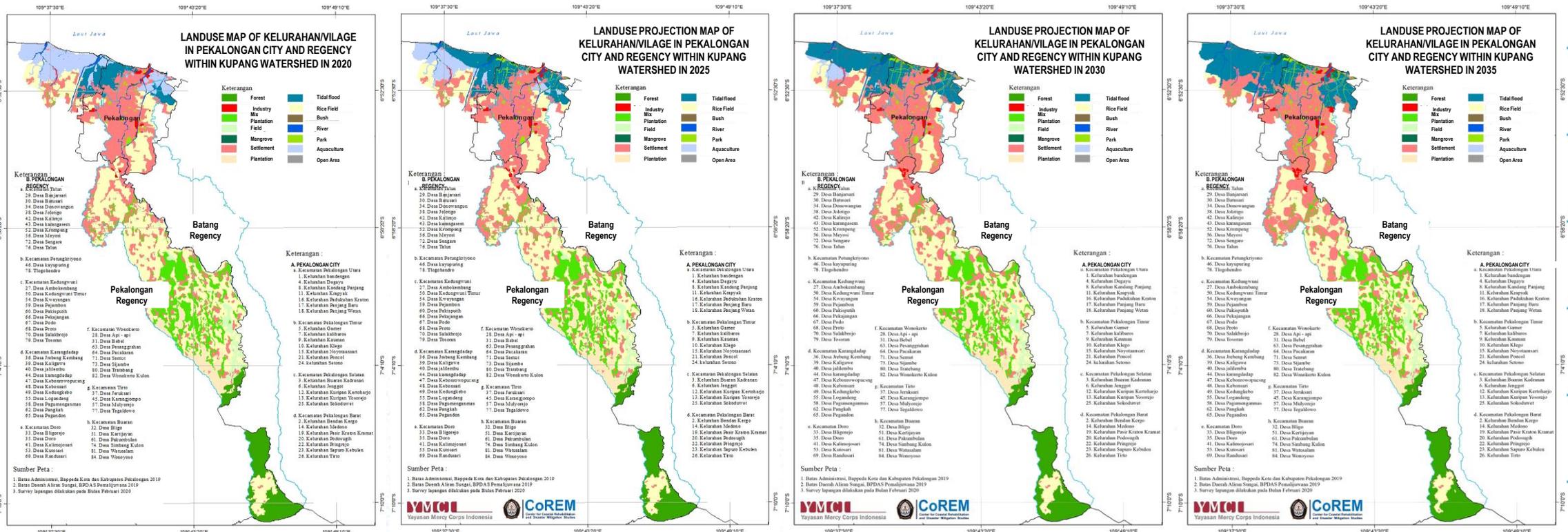
APPENDIX H

Land Use Change Indicators



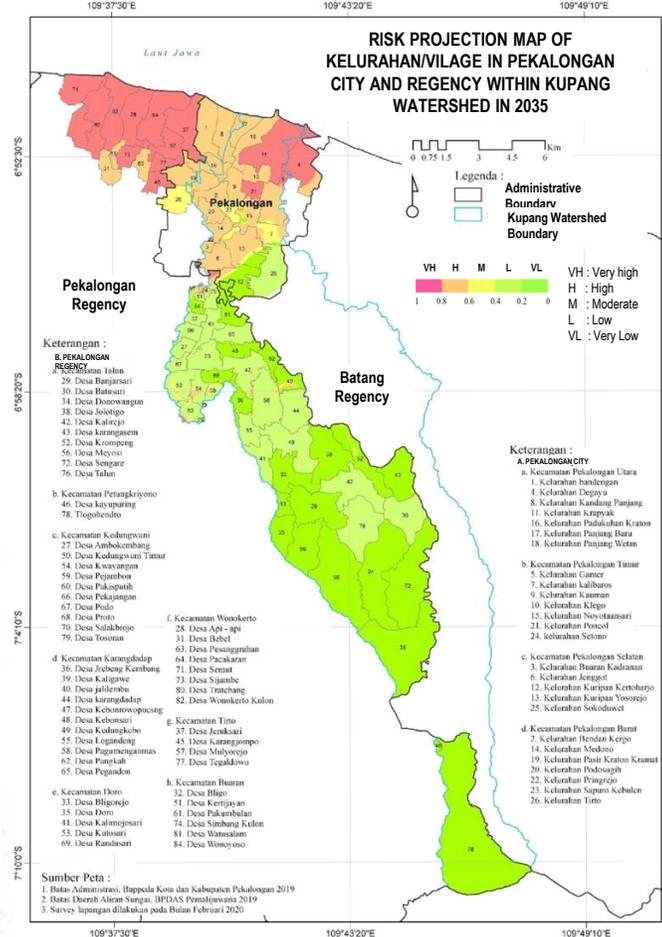
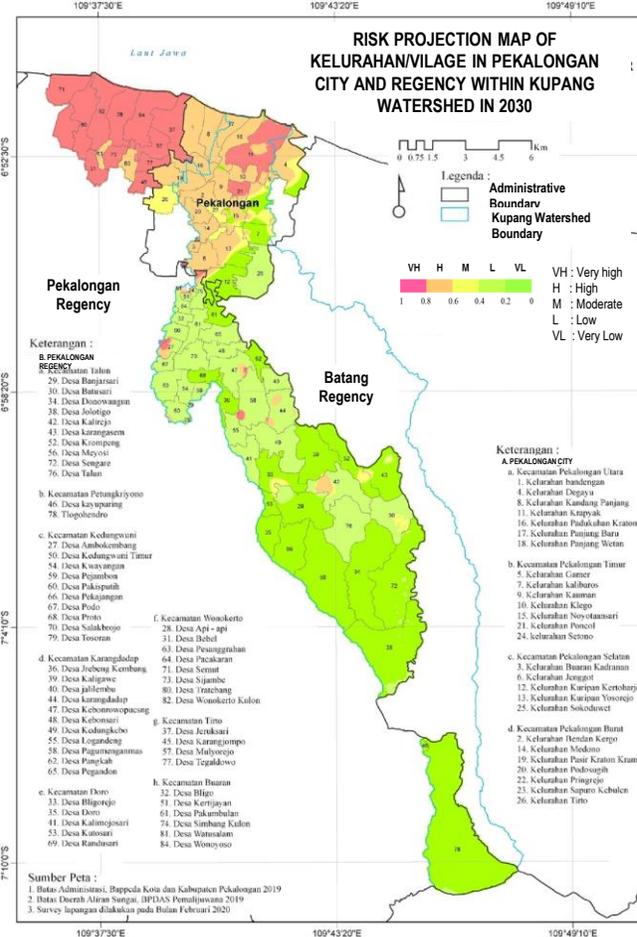
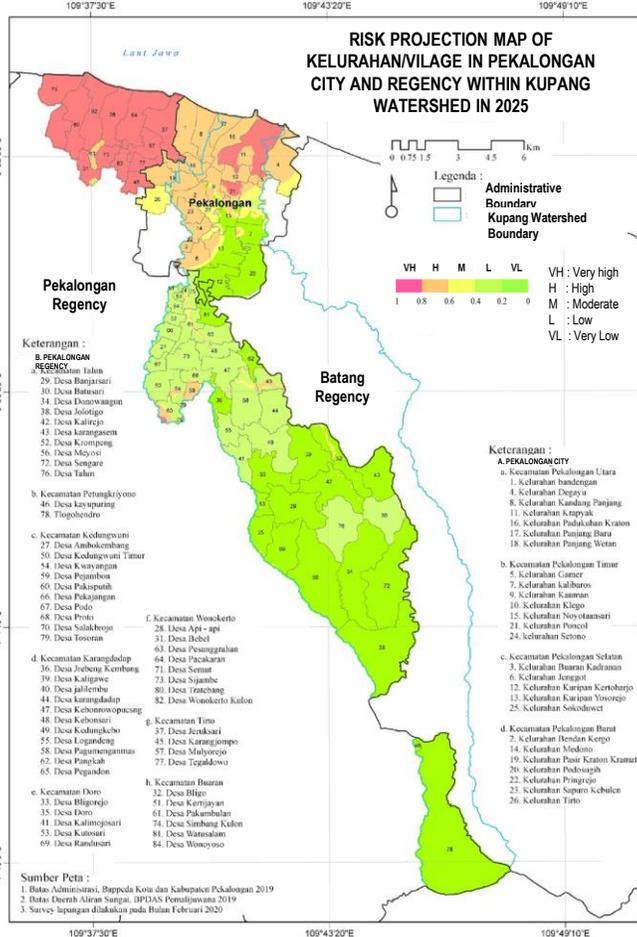
APPENDIX I

Land Use Change Trend by 2020-2035



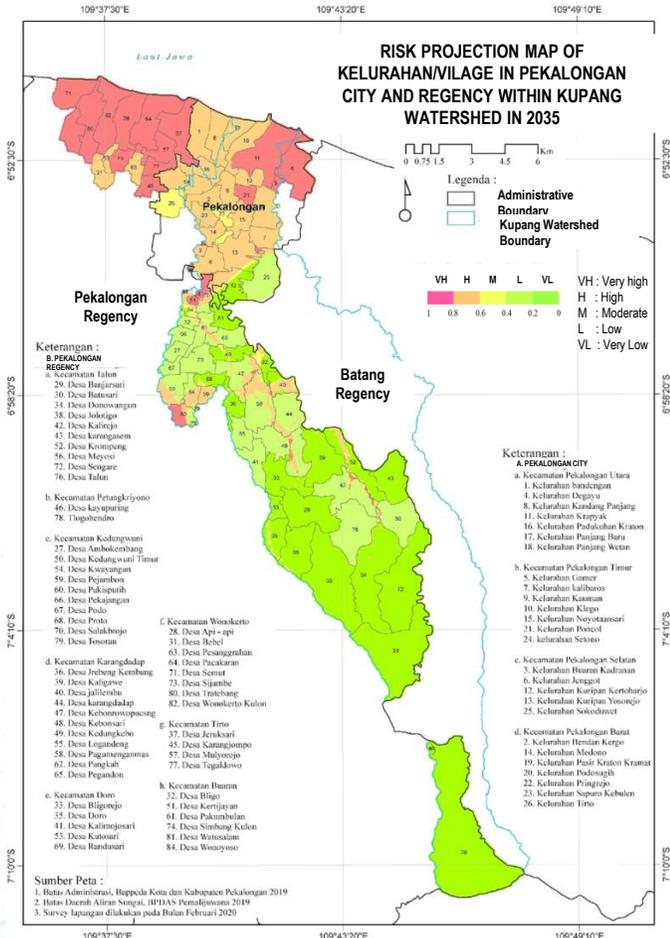
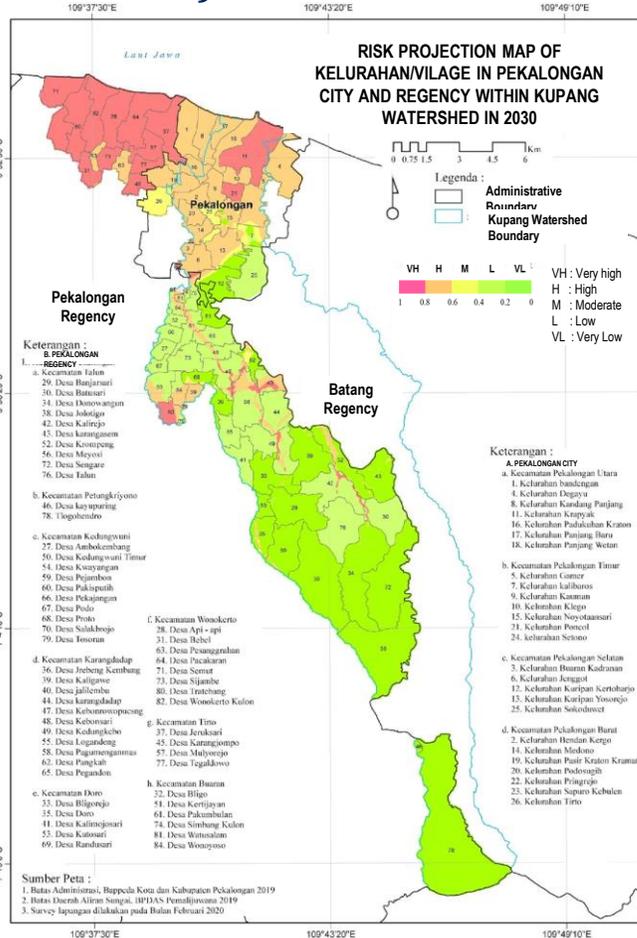
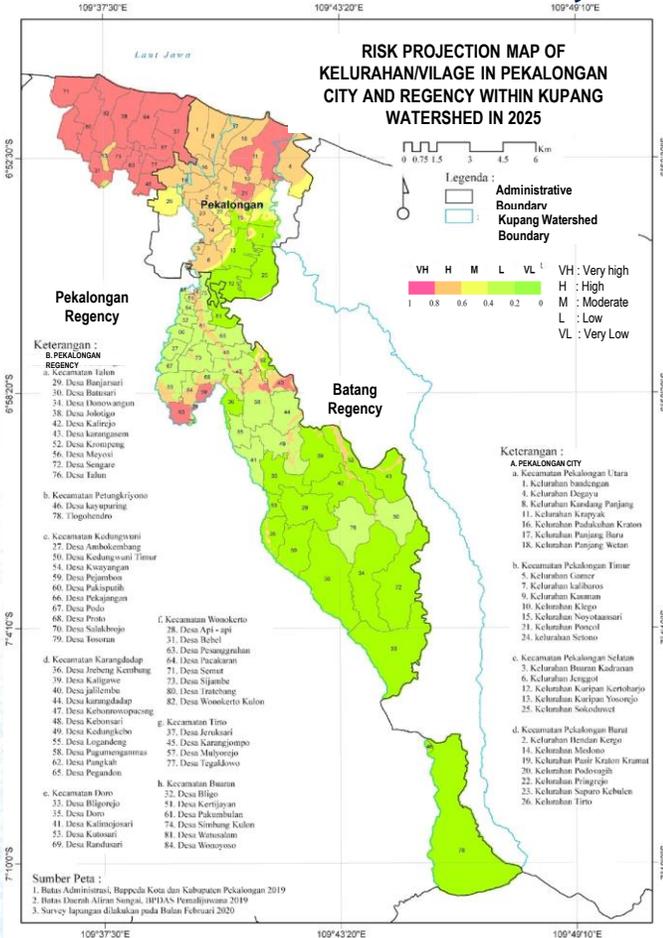
APPENDIX J

Decadal Prediction Flood Risk Projection (2025-2035)



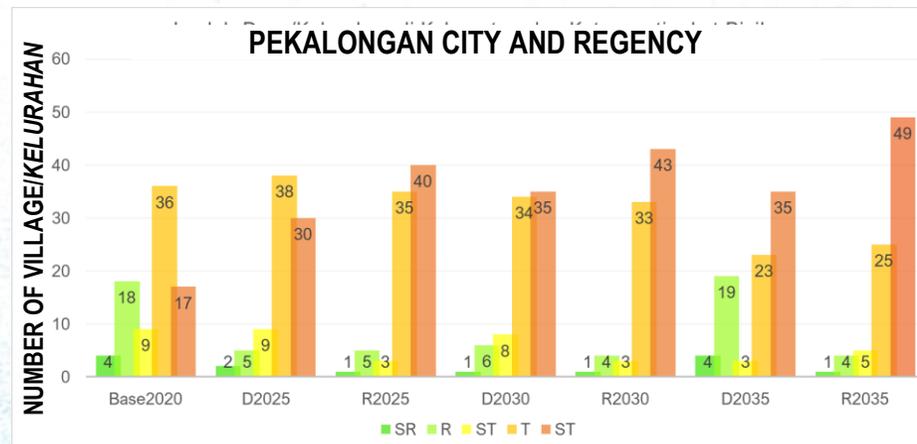
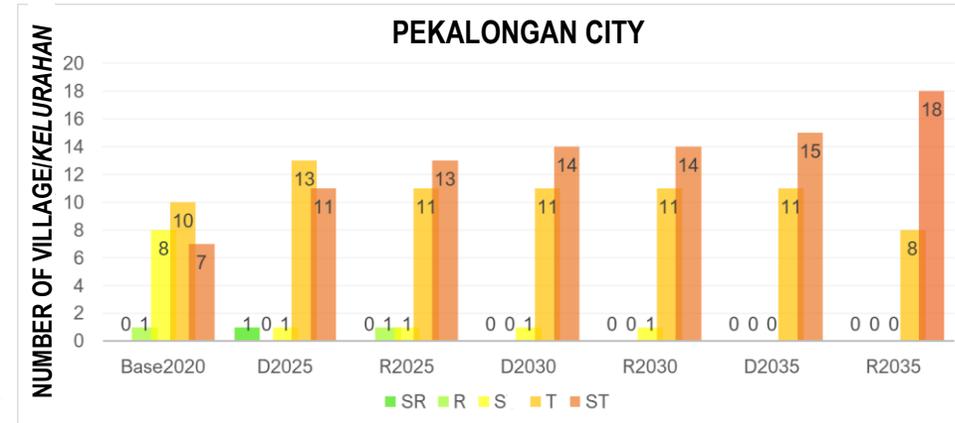
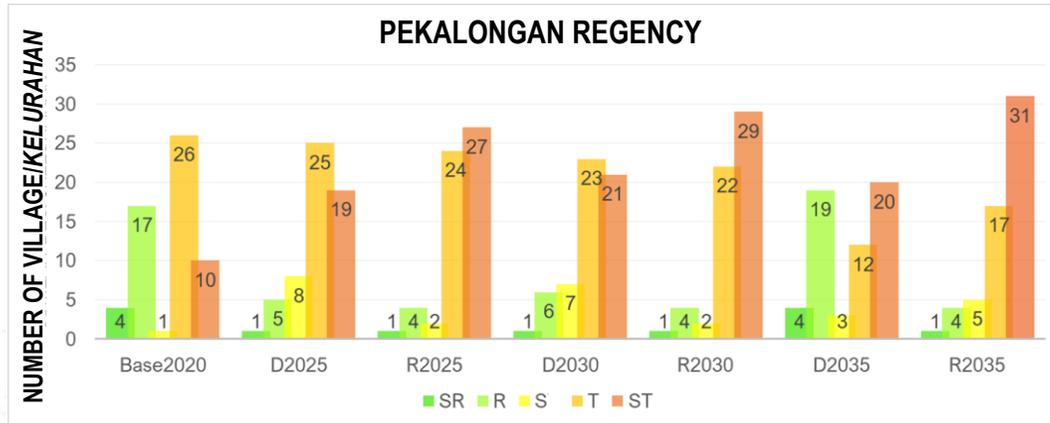
APPENDIX K

RCP 4.5 Scenario Flood Risk Projection (2025-2035)



APPENDIX L

Number of Villages/Kelurahans in Study Location per Risk Level



APPENDIX M

Components and Sub-Components LVI Analysis (1)

MAIN COMPONENTS	SUB COMPONENTS	VALUE	STANDARDIZATION	MIN. VALUE	MAX. VALUE
SOCIO-ECONOMIC	Comparison of productive and unproductive age	35,71	0,38	0,20	0,70
	Last education of the family head < Junior High School	38,10	0,50	0,20	1,00
	Help each other culture	29,76	0,53	0,33	1,00
	The age of the woman who is the female-head of the family	34,52	0,42	0,25	0,75
LIVELIHOOD	Household who works outside their homes? (main livelihood)	30,95	0,45	0,20	1,00
	Household whose main livelihood is agriculture (in a broad sense, such as rice and horticulture farmers, fishermen, and fish farmers)	22,02	0,38	0,20	1,00
	Farmers	8,33	0,27	0,20	1,00
	Fishermen	22,02	0,38	0,20	1,00
	Fish Farmers	12,50	0,30	0,20	1,00
	Batik entrepreneur	30,36	0,44	0,20	1,00
	Household whose main livelihood is OTHER than agriculture (in a broad sense such as farming, fishing, and fish farmers)?	62,50	0,70	0,20	1,00
	The effect of flooding on livelihoods in the village	85,71	0,86	0,00	1,00
	The impact of flooding on people’s livelihoods	63,10	0,70	0,20	1,00

Components and Sub-Components LVI Analysis (2)

MAIN COMPONENTS	SUB COMPONENTS	VALUE	STANDARDIZATION	MIN. VALUE	MAX. VALUE
WATER NEEDS	What is the primary water source for MCK (shower, washing and toilet) needs?	25,00	0,63	0,50	1,00
	Household that self-collect water because they DO NOT served by the public water system (PAM, PAMSIMAS, etc.) ?	14,29	0,26	0,20	0,60
	Household with water access from other public systems?	24,76	0,37	0,17	1,00
	Household with water source from wells, rainwater, and springs?	18,57	0,32	0,17	1,00
	Household that does not have primary water supply?	7,14	0,23	0,20	0,60
	Household daily water consumption?	35,71	0,52	0,25	1,00
	The water needs are supplied by the primary water source/access?	14,29	0,57	0,50	1,00
	If it is NOT sufficient from the primary water source, what is your alternative water source?	58,57	0,65	0,17	1,00
SICKNESS AND DISEASE	Does COVID affect livelihoods?	95,24	0,95	0,00	1,00
	The impact of COVID on livelihoods, please elaborate?	64,29	0,71	0,20	1,00
	How big is the impact of COVID on people's livelihoods?	66,67	0,73	0,20	1,00
	Anyone affected by COVID in the village?	71,43	0,71	0,00	1,00
	Number of people affected by flood-related disease? (reported to kelurahan/village in the last 1 year)	7,62	0,23	0,17	1,00
	Household whose family members suffer from chronic diseases (whether due to flooding or not in the last 1 year)	7,14	0,23	0,17	1,00
	Household whose family members have not worked for 2 weeks or more due to illness due to flooding? (within the last 1 year)	11,90	0,27	0,17	1,00
	COVID management?	41,07	0,53	0,20	1,00

Components and Sub-Components LVI Analysis (3)

MAIN COMPONENTS	SUB COMPONENTS	VALUE	STANDARDIZATION	MIN. VALUE	MAX. VALUE
FLOODS	Highest flood level since 2019 – 2020	33,93	0,47	0,20	1,00
	Lowest flood level since 2019 – 2020	11,90	0,22	0,20	0,40
	Increased flood since 2019 – 2020	10,71	0,29	0,20	1,00
	Number of flood event in the last 1 year	33,33	0,50	0,25	1,00
	Owners who lost their livelihood-related land (productive land) due to flooding (both agricultural land, aquaculture, and entrepreneurial land)	20,63	0,32	0,14	1,00
	Household that lost physical assets (houses or household equipment) during floods	14,29	0,27	0,14	1,00
	Household that lost physical assets (houses or household equipment) during floods	2,98	0,22	0,20	1,00
	Household injured/died due to flooding in the last 3 years	26,19	0,41	0,20	1,00
	Household that demolished its house and rebuilt it? (because of flood)	12,70	0,28	0,20	0,80
	Household that repairs its house because it was affected by a flood?	17,86	0,34	0,20	1,00
	Abandoned house due to flood? (because it can't be occupied)	11,90	0,22	0,20	0,40
	A house with a construction that is not strong enough to withstand flooding?	22,22	0,33	0,20	0,80

Components and Sub-Components LVI Analysis (4)

MAIN COMPONENTS	SUB COMPONENTS	VALUE	STANDARDIZATION	MIN. VALUE	MAX. VALUE
FOOD	Household who depend on self-produced food?	6,67	0,22	0,17	1,00
	Household selling or exchanging (bartering) their food crops for other foods?	2,38	0,21	0,20	0,60
	Diversity index of food crops? (Number of food crops compared to non-food crops)	11,49	0,06	0,02	0,40
	Household who depend on fishing for daily food	8,16	0,26	0,17	1,33
	Food access during the flood?	44,05	0,55	0,20	1,00
DISASTER RELIEF AND MANAGEMENT	Availability of assistance from the government with regards to flooding in the last 1 year (in 2020) ?	9,52	0,10	0,00	1,00
	What kind of government assistance related to flooding in the last 1 year (in 2020)?	61,90	0,70	0,20	1,00
	Household that requested assistance from the government in the last 12 months?	38,69	0,51	0,20	1,00
	Travel time to the nearest health facility? (in minutes)	22,62	0,21	0,14	0,43
	Household with family members in need of care? (due to age, physical/mental condition, illness/disability) (%)	15,87	0,28	0,14	1,00



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