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Regional Climate Change Impacts of Flood Inundation and Evaluation of Several Counter Measures in Japan And Indonesia

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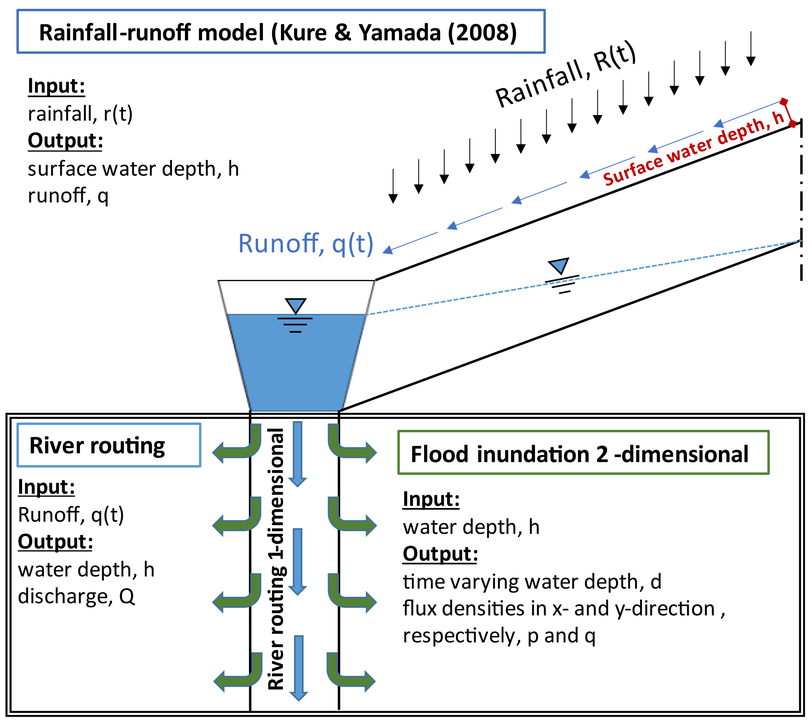
INTRODUCTION

- Global disaster events have increased significantly in recent decades, with 2022 surpassing the average number of flood events from 2002-2021 (CRED, 2023).
- Low-lying coastal cities are especially at risk from flooding.
- Jakarta, a typical coastal urbanized Asian megacity, faces annual floods exacerbated by land subsidence, land use change, sea level rise, inadequate waste management, sedimentation, and climate change.
- Despite flood mitigation efforts since the 1960s, Jakarta continues to struggle with inundation issues.
- Innovative, cost-effective countermeasures are essential for future flood mitigation and preparation.

objective

To assess the impacts of regional climate change on flood inundation and evaluate the effectiveness of various countermeasures in mitigating flood risks in Japan and Indonesia.

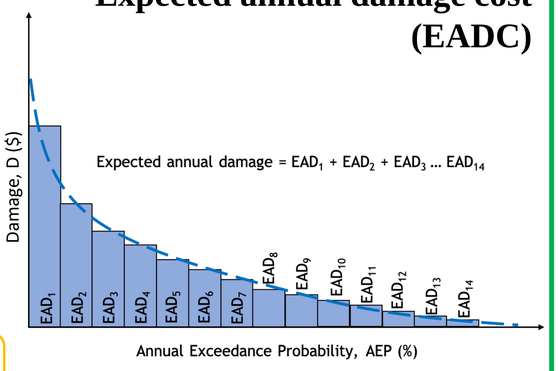
DATA & METHOD



Flood simulations

- **Calibration parameters: Moe et al (2016)**
- **Flood inundation model boundaries:**
  - **Sea level rises**
  - **Land subsidence**
- **Rainfall data: 8 GCMs from CMIP5 (RCP 2.4, 4.6, and 8.5) for return period 2, 5, 10, 25, 50, 100 years.**

Expected annual damage cost (EADC)



- Flood Inundated map
- Land use map
- Damage cost (each land use)

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Affected area based on landuse and height of water

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Calculate **damage cost**

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Calculate for all return period

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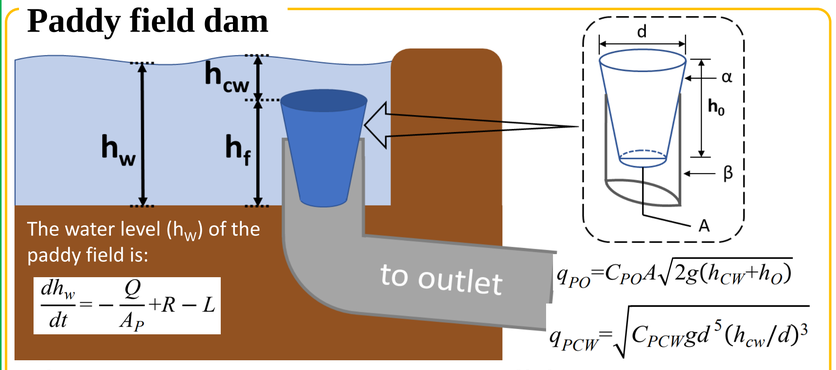
EADC

Paddy field dam



Where:
C_{PO} = coefficient of orifice
C_{PCW} = flow coefficient of cylindrical weir
h_{CW} = height from hole to water level
h_O = height of orifice
d = diameter of hole
A = area of hole
g = gravitational acceleration
q_{PO} = outflow from paddy field
A_P = area of paddy field
R = rainfall
L = sum of infiltration and evapotranspiration

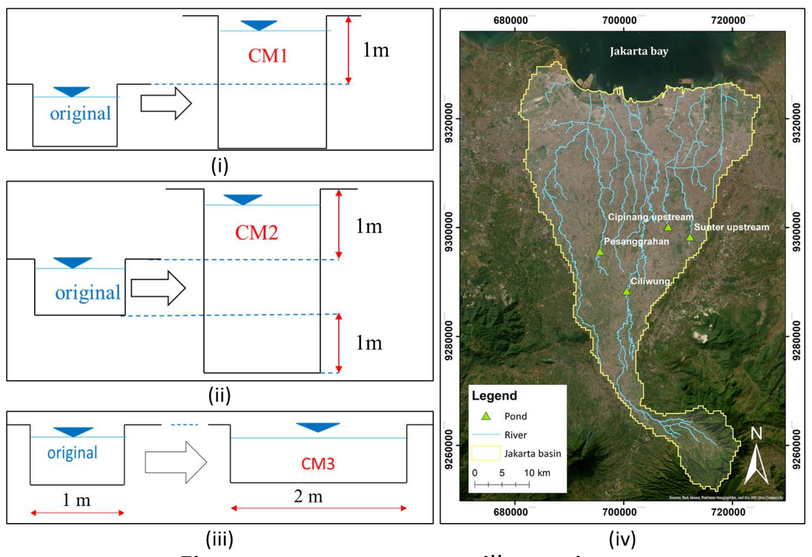


Figure countermeasures illustration

Countermeasure scenarios:

(i) CM1: Leveling the riverbanks 1m
(ii) CM2: Leveling the riverbanks 1m and dredging the riverbed 1m
(iii) CM3: Widening river width 2 times
(iv) CM4: Pond at upstream
(v) CM5: Paddy field dam (PFD)
(vi) CM6: increase paddy field dam area

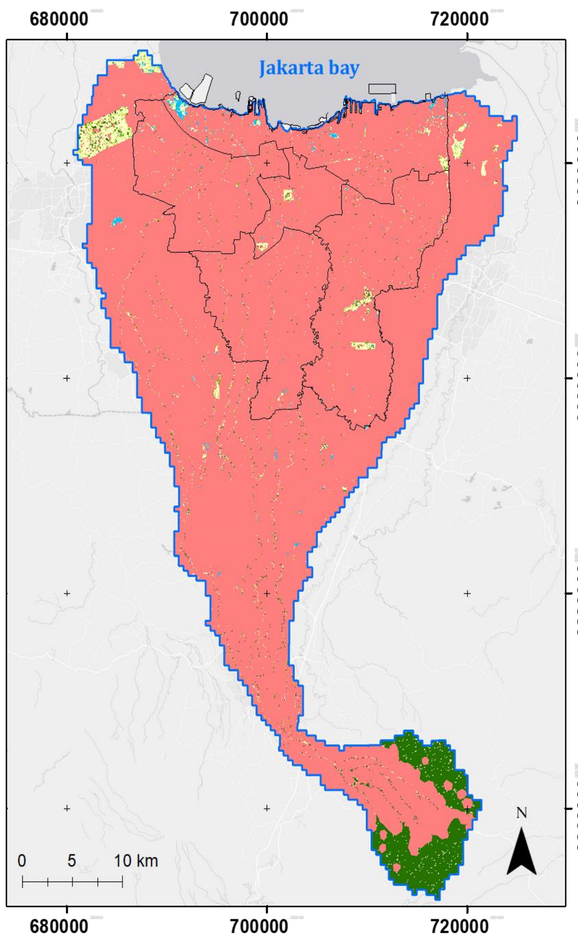
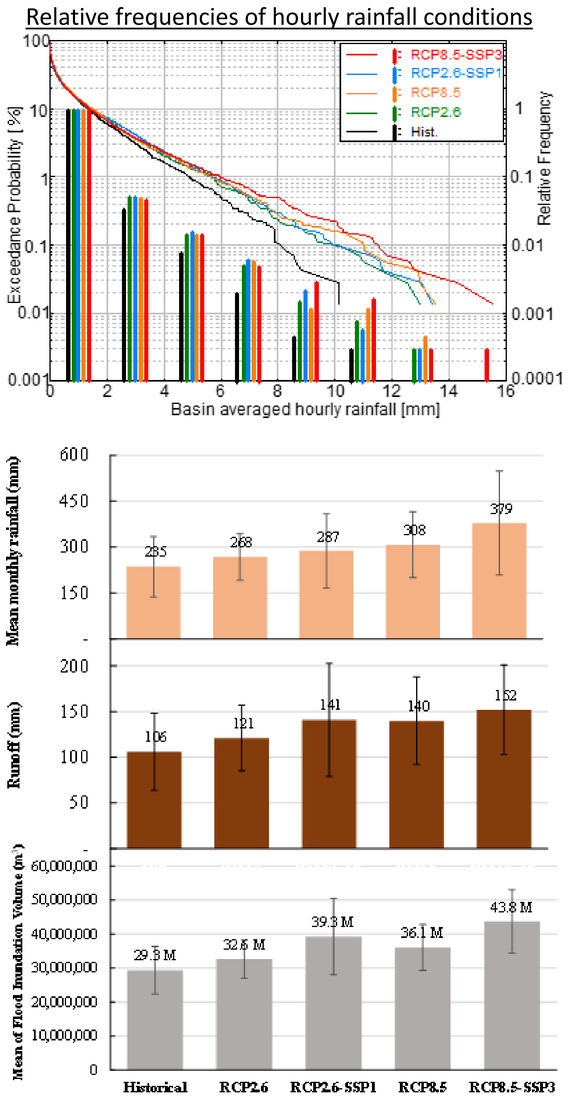


Figure Land use condition of Jakarta basin 2050*
*projected by applying RCP8.5 SSP5 scenario

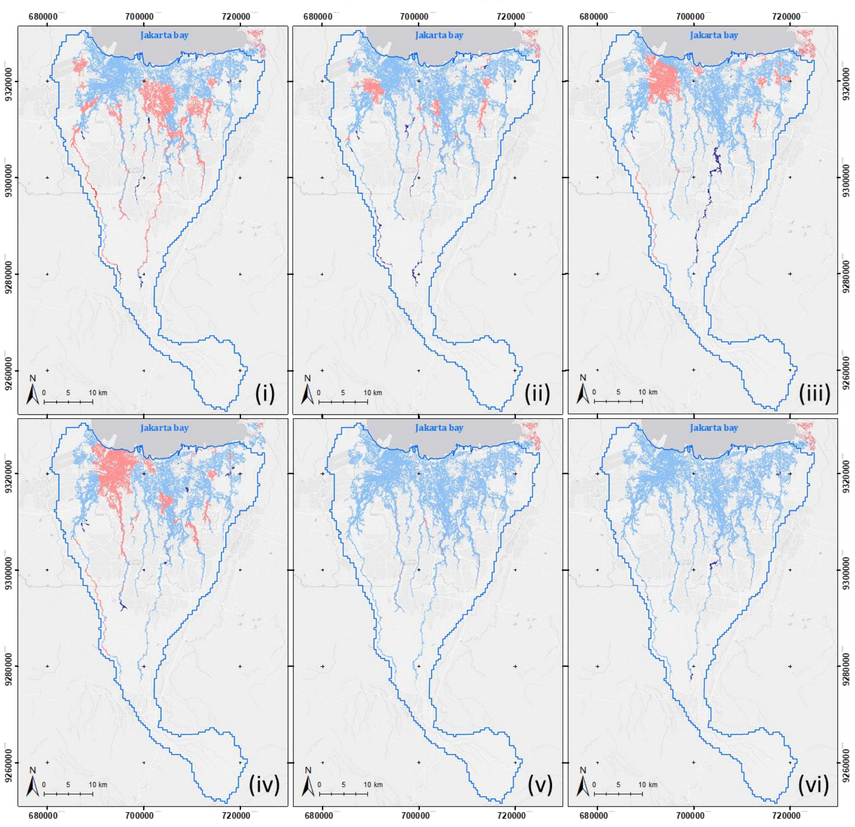
Relative frequencies of hourly rainfall conditions



Comparison of average monthly rainfall, runoff, and flood inundations in each scenario

RESULT

Figure of water level change due to application of countermeasures:



Legend

- Jakarta basin

h-depth (m)

- 1 < increasing
- 0 < increasing < 1
- 0 < decreasing < 1
- 1 < decreasing

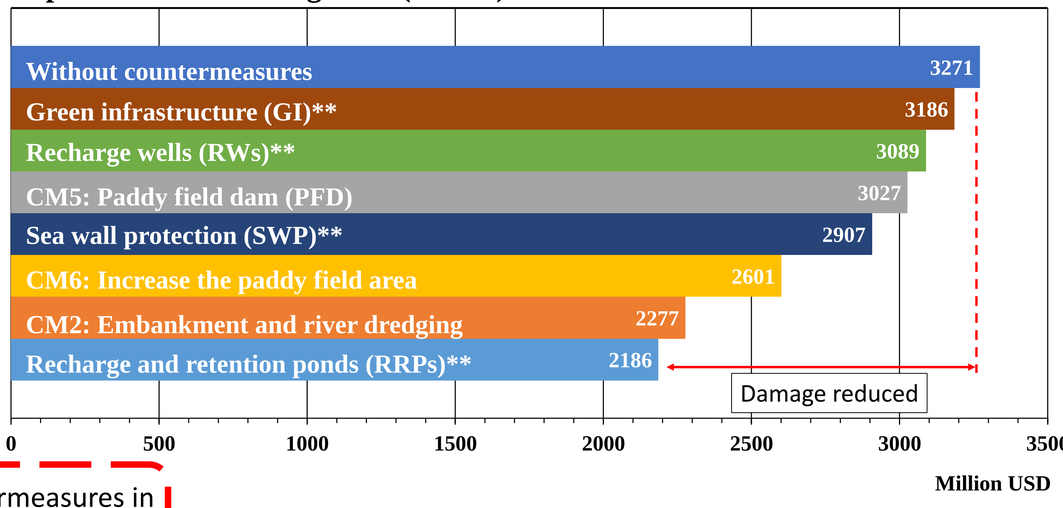
Where,
(i) CM1: embankment;
(ii) CM2: embankment and river dredging;
(iii) CM3: river widening;
(iv) CM4: long storage;
(v) CM5: paddy field dam; and
(vi) CM6: increase the paddy field area

Table of benefit cost ratio for all scenarios

Scenario	Benefit Cost Ratio (BCR)
CM5	2.3
CM6	1.8
CM2	0.09
RRPs**	2.19
RWs**	9.08
SWP**	0.04
GI**	0.004

**Source: Januriyadi et al., 2020

Expected annual damage cost (EADC)



The EADC indicates the effectiveness of countermeasures in reducing inundation, while the BCR reflects their economic feasibility. EADC and BCR values serve as references for evaluating the efficiency or optimality of countermeasures. Lower EADC values and higher BCR values are preferable when selecting the best countermeasure.

Table of inundation reduction for all scenarios

Scenarios	Inundation area (km^2)	Inundation volume (Million m^3)	Percent of volume reduced (%)
Without countermeasure	315.8	708	
CM 1	303.2	680.7	3.9%
CM 2	287.6	631.4	10.8%
CM 3	299.2	654.9	7.5%
CM 4	298.4	673.7	4.8%
CM 5	309.3	690.9	2.4%
CM 6	296	644.4	9%

CONCLUSION

- **All countermeasures can reduce the inundated area in the Jakarta area.**
- **Generally, structural adaptation measures such as embankments, river dredging, green infrastructure, and seawall protection require high investment costs.**
- **The countermeasures involving river development (CM1, CM2, CM3, and CM4) could impact water levels in certain areas, causing an increase.**
- **Paddy Field Dam (PFD) demonstrates its effectiveness as a low-cost flood countermeasure.**
- **The limited paddy field area in the Jakarta basin presents one of the obstacles to implementing Paddy Field Dam.**