PROJECTION OF CLIMATE CHANGE IN INDONESIA: Preliminary analysis for the Bengawan Solo River Basin

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Orientation Seminar on Climate Change Adaptation: In the Pilot Case of Solo River Basin - ICHARM
Outline

- State of the global climate and its change
- Cities – emission – pollution – climate change: Indonesian context
- Impacts of climate change: when hazards meet with vulnerable society
- Future projected climate change in Indonesia
- Specific Climate Change Analysis for the Bengawan River Basin (Preliminary): plots of ETCCDI indices
- Summary
State of the global climate and its change
Recent Global Reports Related With Climate

Present State of the Global Climate

State of the Climate [WMO]

Future Climate [IPCC]

Global Risk Analysis [WEF]

Future Climate

Global risks
Present state of the global climate (WMO)
(Provisional statement)

- 2015–2019 were the five warmest years on record as the long-term warming trend continues
- 1.1 ± 0.1 °C above the preindustrial baseline (1850–1900)

Ocean heat content is at a record high
Countries agreed in Paris agreement to put much effort to limit global warming below 1.5°.

At current rate, will reach 1.5° between 2032 and 2050.

Pathways for not exceeding 1.5°, greenhouse gas emission in 2030: 25-30 Gigaton CO₂ equivalent.

Interpretation: if human stop emitting immediately, chances of not exceeding 1.5° is small.
Global Risk Landscape (WEF)

Global Risk Report 2020

Top three risks in impact and likelihood:

- Extreme weather events
- Failure of climate change mitigation and adaptation
- Natural disasters
Measurement of background CO$_2$ concentration: Indonesia vs Global

- CO$_2$ concentration measured in GAW Kototabang is less than global average concentration.
- Recent measurements:
  - GAW Kototabang: 398.5 ppm,
  - Global average: 402.2 ppm
- But increasing with the same rate (or trend) of 2 ppm / year.
Cities – Emission – Pollution – Climate change: Indonesian Context
Cities and climate: source of GHG emission

Roughly 75% of the fossil-fuel CO2 emissions currently comes from large urban areas and their support systems – which represents > 50% of the total radiative forcing from anthropogenic GHGs.

Cities are the (primary) source of Green House Gases emission

Source: Cities and Climate Change: an urgent agenda, World Bank, 2010
Cities are exposed to multiple weather and climate related hazards

Urban agglomerations at risk of multiple natural hazards (2025)
The urban landscape in Indonesia: population & regional GDP

- **Jakarta**
  - Population: 9.98 M
  - GDP: Rp. 2172 T

- **Surabaya**
  - Population: 2.8 M
  - GDP: Rp. 451 T

- **Medan**
  - Population: 2.46 M
  - GDP: Rp. 186 T

- **Bandung**
  - Population: 2.33 M
  - GDP: Rp. 217 T

- **Makassar**
  - Population: 1.65 M
  - GDP: Rp. 127 T

- **Semarang**
  - Population: 1.62 M
  - GDP: Rp. 145 T

- **Palembang**
  - Population: 1.54 M
  - GDP: Rp. 118 T

- **B. Lampung**
  - Population: 1.16 M
  - GDP: Rp. 47 T

- **Batam**
  - Population: 1.02 M
  - GDP: Rp. 130 T

- **Padang**
  - Population: 0.87 M
  - GDP: Rp. 49 T

Data: Ministry of Domestic Affairs, 2015
### Number of (recorded) hydromet disasters since 2000

<table>
<thead>
<tr>
<th>City</th>
<th>#Flood</th>
<th>#Tides/abration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jakarta</td>
<td>217</td>
<td>7</td>
</tr>
<tr>
<td>Surabaya</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Medan</td>
<td>43</td>
<td>2</td>
</tr>
<tr>
<td>Bandung</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>Makassar</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Semarang</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>Palembang</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>B. Lampung</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Batam</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Padang</td>
<td>36</td>
<td>9</td>
</tr>
</tbody>
</table>

- Recurring floods mostly during rainy season
- (On average) at least one event annually
- Jakarta is the most impacted by flood, related to uncontrolled urbanization

Data: National Disaster Management Agency (BNPB, 2018)
The urban landscape in Indonesia: pollutant and acid rain

There is a relation between the level of pollution and the acidity of rainfall.

Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
The urban landscape in Indonesia: pollutant and acid rain

Most acid rain:
JKT, BDG

Most polluted:
JKT, SMG

Rainy season compared to dry season:
• More acidic
• Less TSP

Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
The urban landscape in Indonesia:
pollutant and economy

Urbanization drives pollution in big cities:

Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
The urban landscape in Indonesia: pollutant and economy

Data:
Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
- Measurement of temperature in Jakarta also showing increasing trend.
- Higher trend than global average (1.4x)
Recent temperature anomaly

Anomaly with respect to climatological reference 1981-2010

Data: Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
Trend of heavy rainfall (> 50mm/day)

Data: Badan Meteorologi Klimatologi dan Geofisika (BMKG, 2018)
Impacts of Climate Change: When hazards meet with vulnerable society
Data from BNPB (DMA) in 2017 there were 2372 disaster events recorded. Dominated by floods and landslides.
BENCANA TAHUN 2018
1 JANUARI 2018 - 31 DESEMBER 2018


TOTAL BENCANA TAHUN 2018
1 Januari 2018 - 31 Desember 2018
2.572

KERUSAKAN AKIBAT BENCANA TAHUN 2018
320 Ribu
RUMAH RUSSAK
1.736
FASILITAS PENDIDIKAN RUSSAK
106
FASILITAS KESEHATAN RUSSAK
857
FASILITAS PERIBADATAN RUSSAK

DAMPANK BENCANA TAHUN 2018:
4,814 JIWA MENINGGAL DUNIA & HILANG
10,239 Juta JIWA TERDAMPAK & MENGUNGSI
Proportion of natural disaster types

Numbers since 1980, from BNPB

HYDROMET RELATED DISASTERS: 96%
Jakarta, Indonesia 6 Februari 2007

Recurring major floods:
- 1996
- 2002
- 2007
- 2013
- 2015
- 2019
- 2020

City vulnerabilities to climate change in slum area
- Is urbanization contributing to this as well?
- Unskilled urban people live in most of the slum area
West Java, Indonesia  
September 23, 2016

At least 33 people were killed in devastating flash floods and landslides.

Rural vulnerability induced by extreme weather due to the impact of climate change.
Rongkop, Central Java, Indonesia  
September 19, 2015

- Lack of water resources facilities and infrastructure in the rural area drive persistently urbanization to the city.
- Rural vulnerability to drought exacerbated by climate change.
- Threatening food security.
Future Projected Climate Change in Indonesia
CORDEX-SEA Consortium

The CORDEX-SEA is a collaborative climate downscaling initiative over the Southeast Asia, involving a number of countries in the region, aiming to develop detailed regional climate information necessary for vulnerability, impact and adaptation assessment.

The initiative was designed to downscale a number of CMIP5 Global Climate Model (GCM) using Regional Climate Model (RegCM4), employing Representative Concentration Pathways (RCPs) 4.5 and 8.5, respectively.

Participating members: 11 countries, 18 institutions
Numbers of GCM: 9 GCMs
Climate projections: max temperature
Climate projections: max temperature

From CORDEX-SEA models:
1. CNRM5
2. CSIRO-MK3.6
3. EC-EARTH
4. GFDL
5. IPSL
6. MPI
Climate projections: rainfall

2020-2034

2030-2045

Precipitation Change mm/day
Climate projections: rainfall

Images from Supari et al (2018)

Prolonged dry spell in end century

Increased extreme rainfall (R50mm)
Remarks:
What does climate change mean to Indonesia

• Continued increase of temperature, with increasing diurnal/daily temperature range (Tmax increase higher than Tmin).

• Increasing extreme rainfall frequency, especially during rainy season (Dec-Jan-Feb), may lead to flooding event when vulnerability is high.

• Longer dry season, during mid year period (Jun-Jul-Aug).

• Drying tendency for southern equator part:
  • Calls for better water resources management.
  • Increased risk for forest fire threat in peatland areas.
Specific Climate Change Analysis for the Bengawan River Basin (Preliminary)
Monthly Rainfall Climatology in Bengawan Solo River Basin

From gridded precip dataset

Climatology Bengawan Solo River Basin:
Monthly TXX

txx_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly PRCPTOT

prcptot_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly CWD

cwd_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly CDD

cdd_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly RX1DAY

rx1day_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly RX5DAY

rx5day_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly R10MM

r10mm_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Monthly R20MM

r20mm_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
r30mm_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Seasonal PRCPTOT, RCP4.5

RCP4.5, prcptot_MON difference from baseline period 1986 - 2005.
Seasonal PRCPTOT, RCP8.5

RCP8.5, prcptot_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Seasonal CWD, RCP4.5

RCP4.5, cwd_MON difference from baseline period 1986 - 2005.

DJF, 2011 - 2040
MAM, 2011 - 2040
JJA, 2011 - 2040
SON, 2011 - 2040

DJF, 2041 - 2070
MAM, 2041 - 2070
JJA, 2041 - 2070
SON, 2041 - 2070

DJF, 2071 - 2100
MAM, 2071 - 2100
JJA, 2071 - 2100
SON, 2071 - 2100

CORDEX-SEA ensemble from BMKG
Seasonal CWD, RCP8.5

RCP8.5, cwd_MON difference from baseline period 1986 - 2005.

DJF, 2011 - 2040

MAM, 2011 - 2040

JJA, 2011 - 2040

SON, 2011 - 2040

DJF, 2041 - 2070

MAM, 2041 - 2070

JJA, 2041 - 2070

SON, 2041 - 2070

DJF, 2071 - 2100

MAM, 2071 - 2100

JJA, 2071 - 2100

SON, 2071 - 2100

CORDEX-SEA ensemble from BMKG
Seasonal CDD, RCP4.5

RCP4.5, cdd_MON difference from baseline period 1986 - 2005.
Seasonal CDD, RCP8.5

RCP8.5, cdd_MON difference from baseline period 1986 - 2005.
Seasonal RX1DAY, RCP4.5

RCP4.5, rx1day_MON difference from baseline period 1986 - 2005.
Seasonal RX1DAY, RCP8.5

RCP8.5, rx1day_MON difference from baseline period 1986 - 2005.

DJF, 2011 - 2040

MAM, 2011 - 2040

JJA, 2011 - 2040

SON, 2011 - 2040

DJF, 2041 - 2070

MAM, 2041 - 2070

JJA, 2041 - 2070

SON, 2041 - 2070

DJF, 2071 - 2100

MAM, 2071 - 2100

JJA, 2071 - 2100

SON, 2071 - 2100

CORDEX-SEA ensemble from BMKG
Seasonal RX5DAY, RCP4.5

RCP4.5, rx5day_MON difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Seasonal RX5DAY, RCP8.5

RCP8.5, rx5day_MON difference from baseline period 1986 - 2005.
Annual R95P

RCP4.5, r95p_ANN difference from baseline period 1986 - 2005.

RCP8.5, r95p_ANN difference from baseline period 1986 - 2005.
Annual R99P

RCP4.5, r99p_ANN difference from baseline period 1986 - 2005.

RCP8.5, r99p_ANN difference from baseline period 1986 - 2005.

CORDEX-SEA ensemble from BMKG
Seasonal SPI3, RCP4.5

RCP4.5, SPI3 difference from baseline period 1986 - 2005.
Seasonal SPI3, RCP8.5

RCP8.5, SPI3 difference from baseline period 1986 - 2005.

DJF, 2011 - 2040
MAM, 2011 - 2040
JJA, 2011 - 2040
SON, 2011 - 2040

DJF, 2041 - 2070
MAM, 2041 - 2070
JJA, 2041 - 2070
SON, 2041 - 2070

DJF, 2071 - 2100
MAM, 2071 - 2100
JJA, 2071 - 2100
SON, 2071 - 2100

CORDEX-SEA ensemble from BMKG
Seasonal SPI6, RCP8.5

RCP8.5, SPI6 difference from baseline period 1986 - 2005.

DJF, 2011 - 2040
MAM, 2011 - 2040
JJA, 2011 - 2040
SON, 2011 - 2040

DJF, 2041 - 2070
MAM, 2041 - 2070
JJA, 2041 - 2070
SON, 2041 - 2070

DJF, 2071 - 2100
MAM, 2071 - 2100
JJA, 2071 - 2100
SON, 2071 - 2100

CORDEX-SEA ensemble from BMKG
Seasonal SPI12, RCP8.5

RCP8.5, SPI12 difference from baseline period 1986 - 2005.
Summary: For Bengawan Solo RB

• Temperature rise for both RCP4.5 and RCP8.5.

• Decay of PRCPTOT towards the end of the century, stronger decay for RCP8.5. Especially during for MAM season.

• Decrease (increase) of CWD (CDD) especially during MAM, JJA and SON. Not so much during DJF.

• Trend of extreme (RX1DAY & RX5DAY): tendency to increase for early century and decrease towards the end of century. Strongest decrease during MAM season.

• Flooding and drought are the opposite faces of the same coin: Should be managed together in-light of climate change. Storing water during rainy seasons (including the flood management) to mitigate drought impacts during dry seasons.
Thank you

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