GEOSS Joint Asia-Africa Water Cycle Symposium

Ito International Research Center. Ito Hall, University of Tokyo,
Hongo Campus, 25-27 November 2013.

INDONESIA

Country Report

Kusuma, MSB, et.al. Water Res Eng, FCEE, ITB

Recent Activities

- **Indonesia** is an archipelago country which consist of 17 000 tropical island where some of them are vulnerable to flood and drought due to both land use change and climate change impact
- Types of Activities :
  - Research for improving capacity in assessing the flood and drought.
  - Community services for disseminating and implementing research results.
  - Education for improving the curricula and academic atmosphere.
- **Partner** :
  - Government :
    - Central (Related Ministry eg Public Work, Environment, BAPPENAS) and Local Government (Province/Regency)
    - River/Reservoir Authority, BNPB (National Board of Disaster Management) and BMKG (Meteorological, Climatological and Geophysical Agency)
    - State own company
  - Non Government (National and International) :
    - Universities, Research Institution and Association
    - NGO and Private
- **Focus activity :**
  - **Selected Case Study :** based on resources availability and prio
  - **2011-2013 : Citarum River Basin** is one of the priority

Source : Google map

- **Anomaly in Current Climate Condition**
  - Flood in dry season period occurred in some areas
  - Drought during the wetr season
- In November 2007, the Indonesian Government published the **National Action Plan on Climate Change (RAN-PI)**, which contains initial guidance for a multi-sectoral coordination effort designed to address jointly the challenges of mitigation and adaptation to climate change
- In December 2007, Bappenas (the National Development Planning Agency) published a document titled "**National Development Planning: Indonesian Responses to Climate Change1”.** The document is intended to strengthen and reinforce the RPJMN (National Medium-Term Development Plan) 2010-2014
- Starting the effort with simple method and then improving for further assessment

Flood and Drought in Citarum River Basin

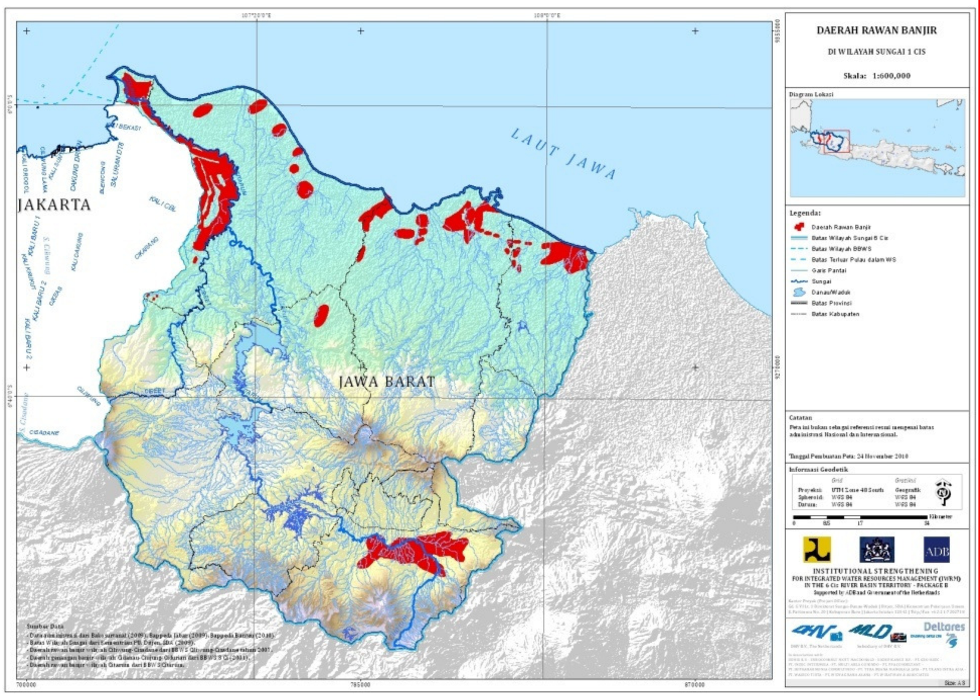
Asian Water Cycle Initiative

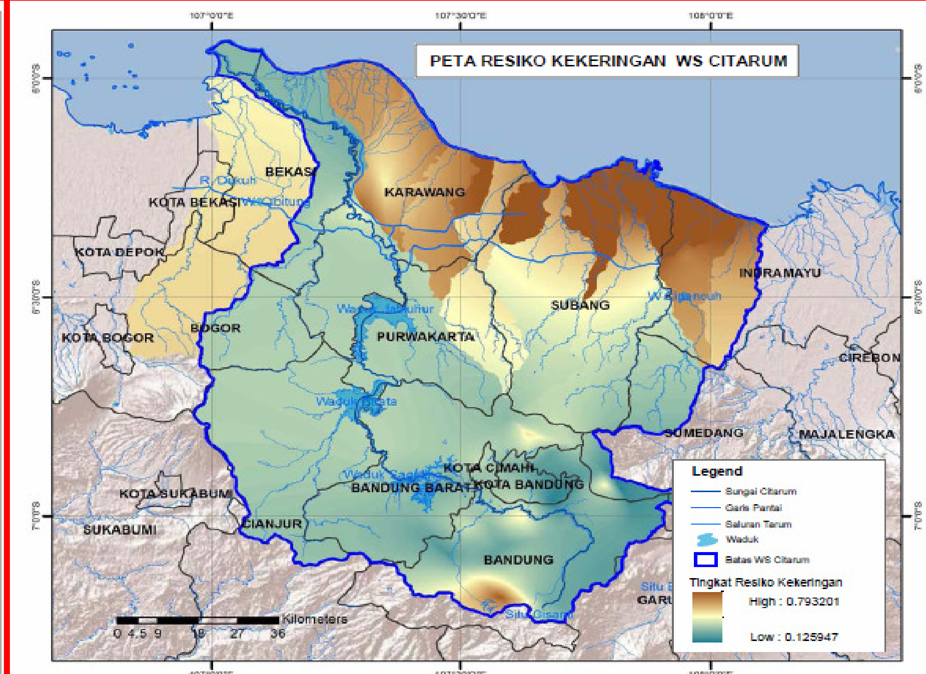
INDONESIA

2013

Flood Index (Citarum Atlas, 2012)

Drought Risk (Citarum Atlas, 2012)





Sumber: PSDA Provinsi Jawa Barat & Hasil Analisa RCMU Bappenas

Research under The Program of Acceleration and Expansion Indonesia Economic Development (MP3EI) 2011-2025:

"Preparedness Efforts in Flood Control for Climate Change Adaptation in The Upper Citarum River Basin, West Java, Indonesia"

Flood in Baleendah subdistrict, Bandung district 2010

Flooded alleyway between houses, Bandung district 2010

Flood in Andir Village, Bandung district 2010

Mud in front of kelurahan office after flood in Dayeuh Kolot subdistrict, Bandung district 2010

Current Event in 2012

Water Scarcity

INDONESIA

Jatiluhur, Citarum River, West Java

Upper part of Citarum River, West Java

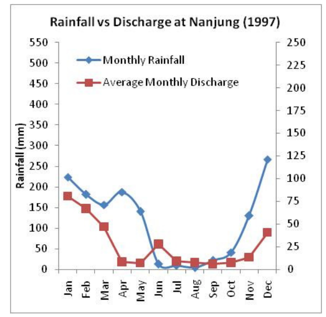
Recent Activities

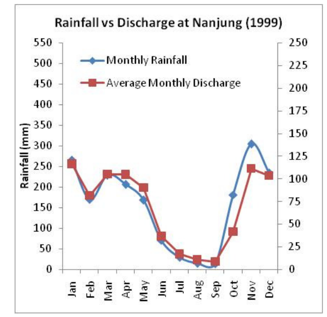
- **Citarum River Basin** is one of the strategic Basins in West Java, Indonesia. Citarum River flows from the mountainous area in Bandung, through the three cascade dams: **Saguling**, **Cirata**, and **Jatiluhur**, before finally flows to Java Sea.
- **Upper Citarum River Basin** is a plateau area surrounded by mountain range which forms a basin which flows into Saguling Dam.
- During rainy season, flood disaster often occurs around the Citarum River which flows through Bandung Regency. Nevertheless, lack of water supply from Upper Citarum River Basin during dry season might disturb water supply for irrigation area in Karawang and Indramayu.
- Climate Change Mitigation which in Indonesia mainly associated with flood in wet season and drought in dry season has to deals with common problems, for example:
- 1) lack of hydrological data;
- 2) high discrepancy in hydrology/drainage computation result using the common computation method;
- 3) unreliable design of drainage facilities, etc.
- This study emphasizes the importance of solving those kinds of problems for Climate Change Mitigation in the future, especially in Citarum River Basin

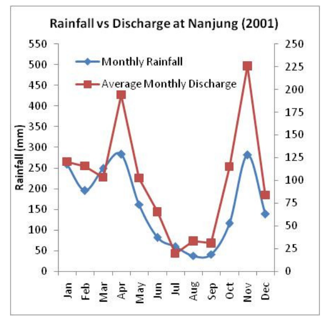
Current Condition:

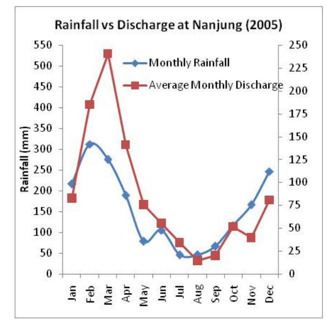
Rainfall runoff characteristic in Citarum River Basin

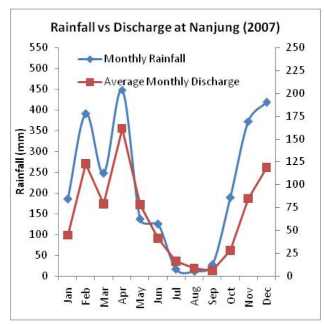
Monthly rainfall seems to have a strong correlation with monthly discharge which indicates the typical of runoff in developed area with high variation between wet and dry season and relatively low base flow

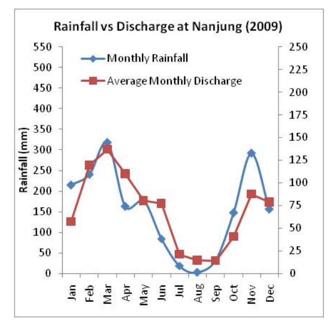






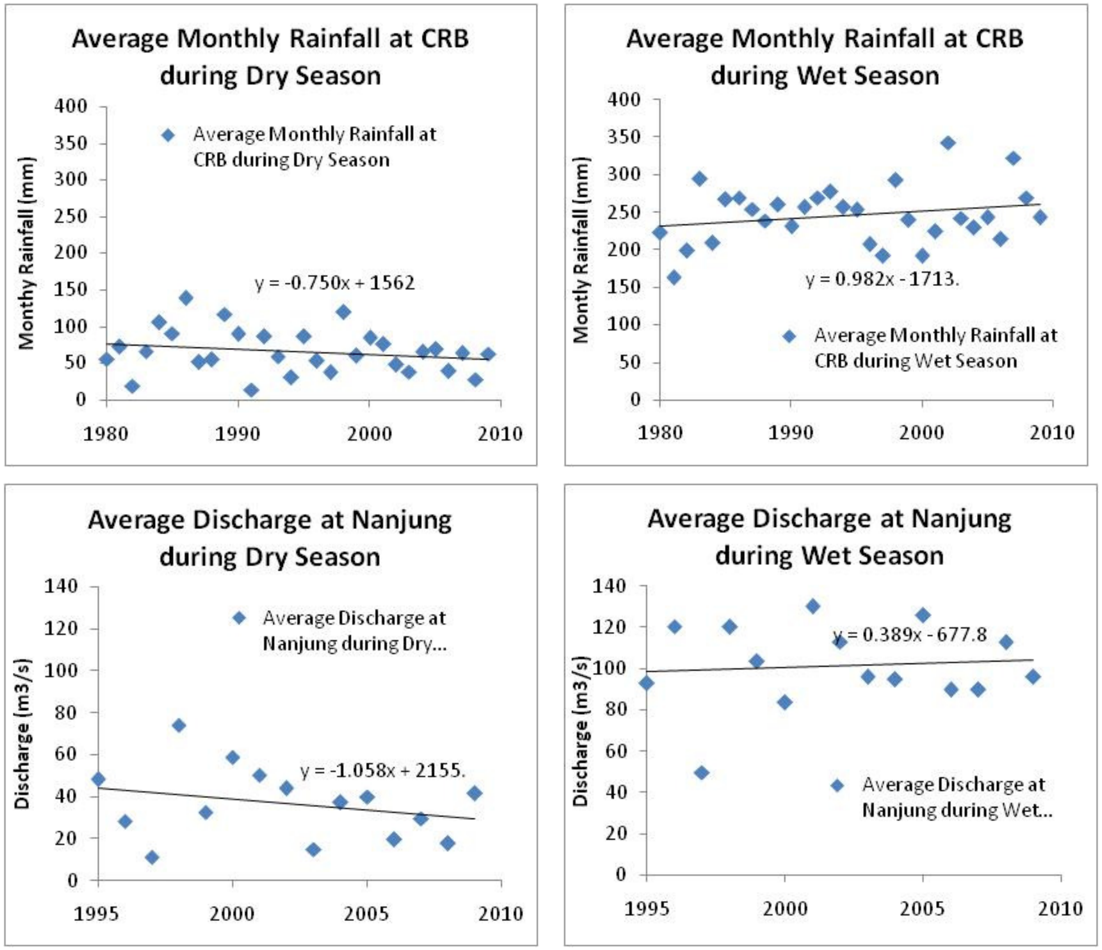






Recent Activities

Average rainfall and discharge during wet season tends to increase, while the average of rainfall and discharge during dry season tends to decrease.



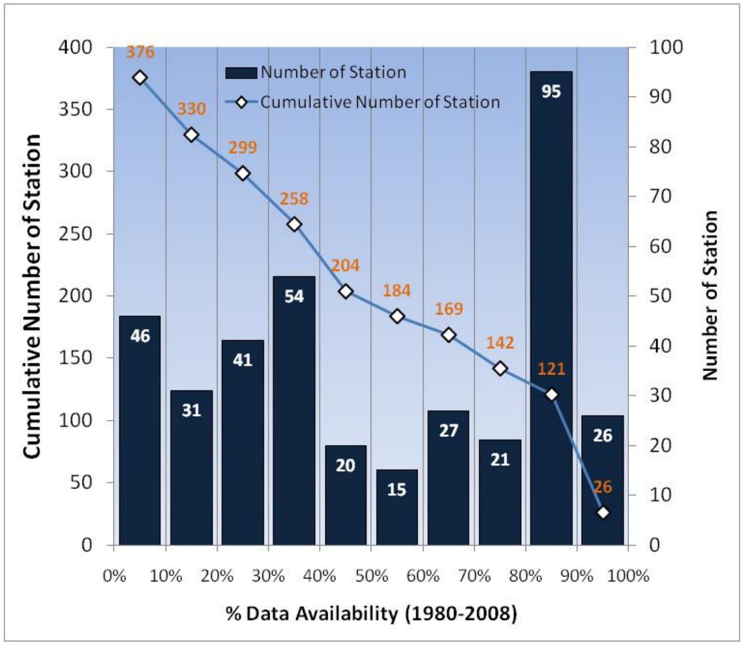
Hydrological data availability

Analysis from 376 rainfall stations in Citarum River Basin from different data sources for the period of 1980-2008 shows that:

1)Only 26 stations (6.9% of the total rainfall stations) consist of very good data record with data availability more than 90%;

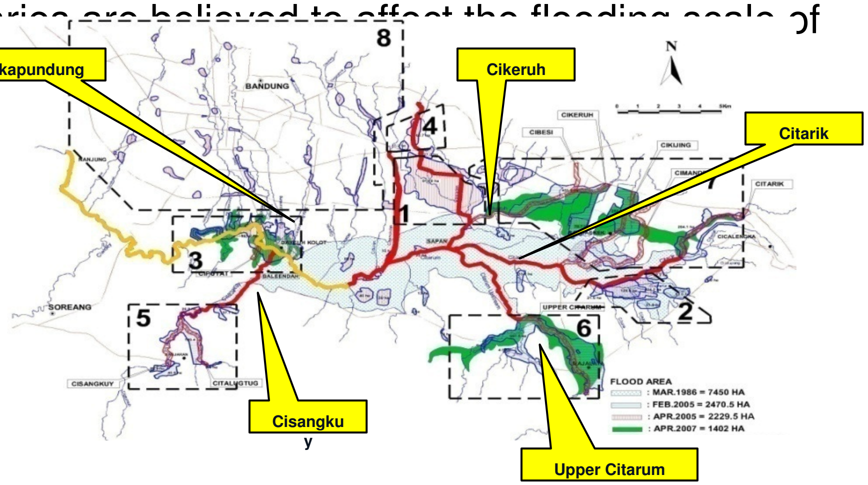
2)142 stations (37.8% of the total rainfall stations) consist of relatively good data records with data availability more 70%;

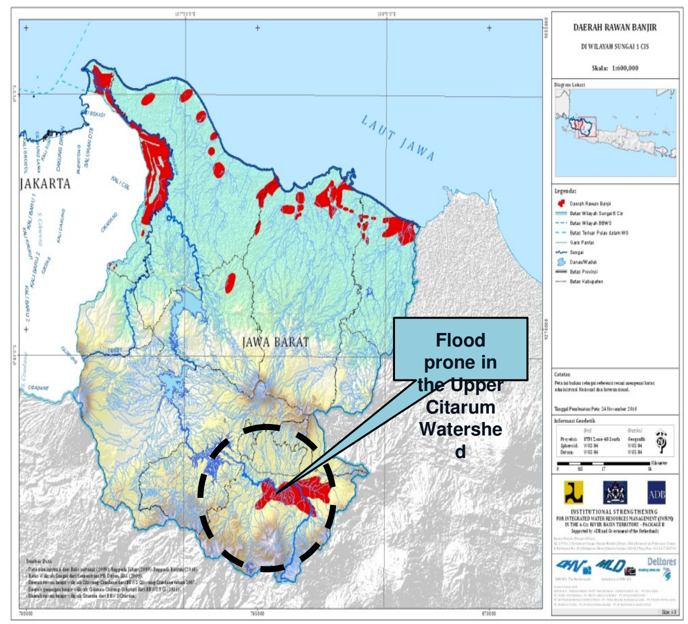
3)3) 192 stations (51.2% of the total rainfall stations) consist of data records with data availability less than 50%.



Flood in Upper Part of Citarum River

- Hydrological characteristics of the Citarum watershed are categorized into the northern and southern parts with time variability and different concentrations of rainfall.
- In the upstream of the Citarum River, the main river flow is affected by the thirteen tributaries. These tributaries are believed to affect the flooding scale of the

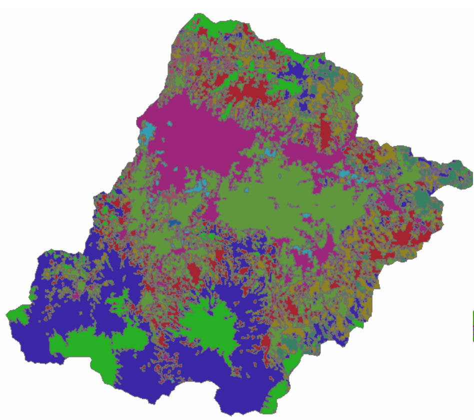




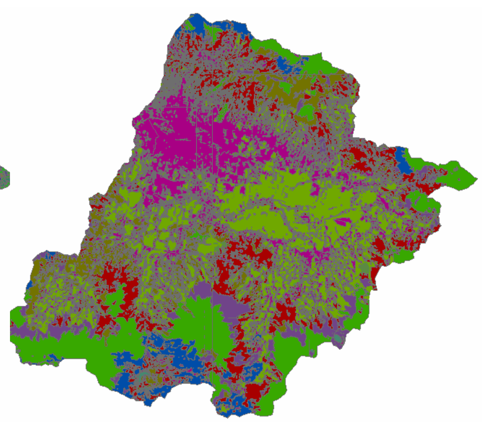
Upper Citarum River Basin

Flood in Upper Part of Citarum River

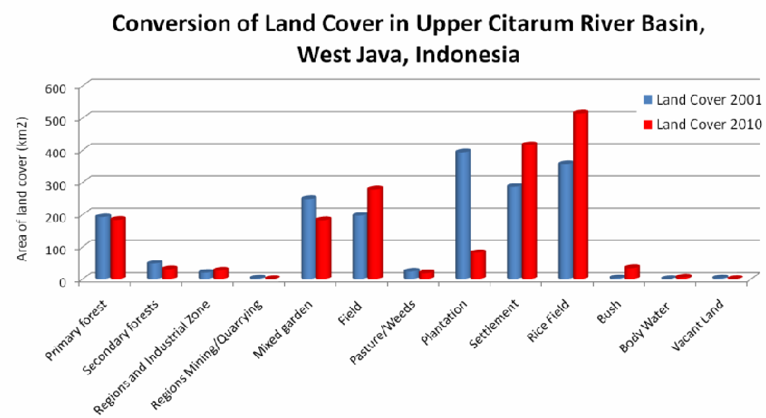
- This zone, nowadays, has rapidly changed into a densely populated area of Bandung. The conversion of natural areas into an urban region has led to flooding in the area. This flooding problem has been the research subject of experts in water resources engineering in order to find solutions.
- Data analysis of conversion of land cover shows that there are changes in land cover in the Upper Citarum River Basin especially in the growing residential areas.



Upper Citarum River Basin land cover 2001

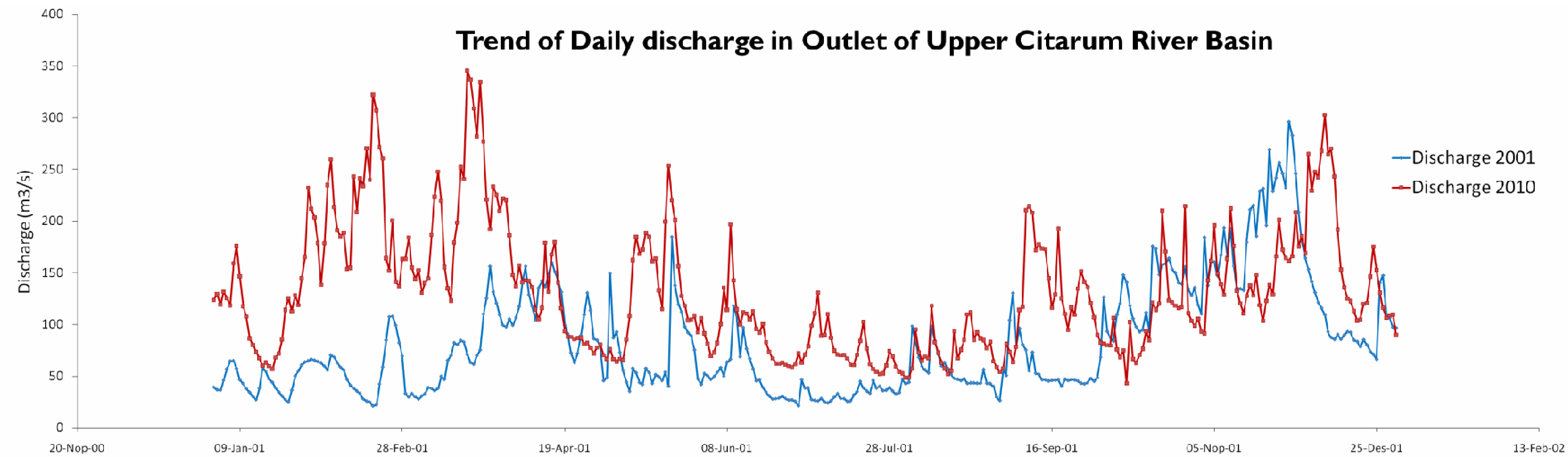


Upper Citarum River Basin land cover 2010



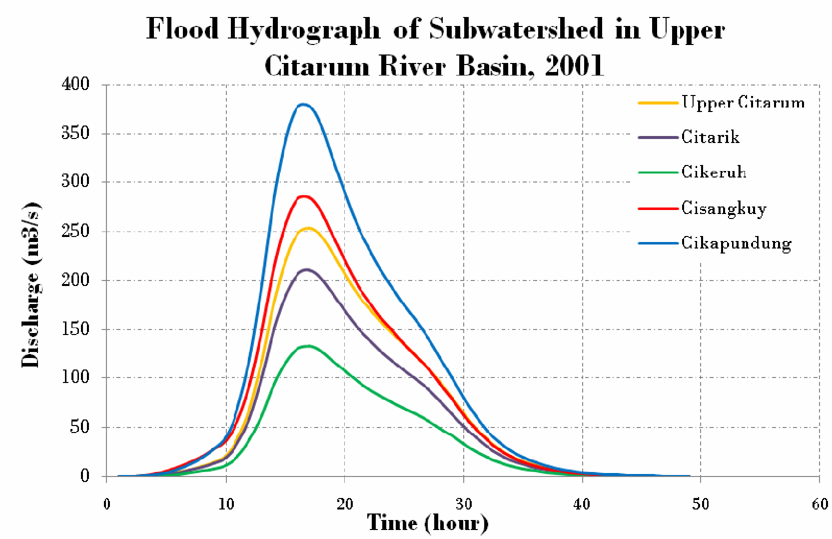
Flood in Upper Part of Citarum River

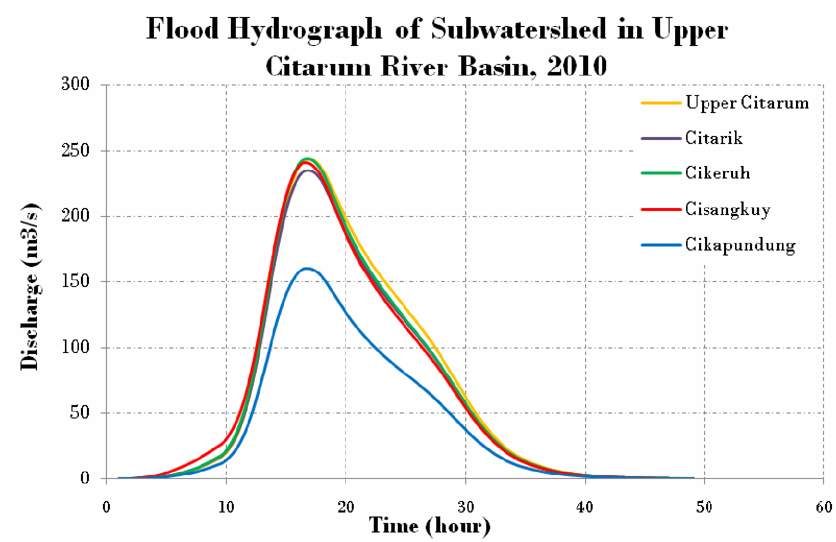
- This figure is trend of daily discharge in outlet of Upper Citarum River Basin in Sta. Nanjung .
- This trend is between discharge in 2001 and discharge in 2010
- It shown that in 2010 increased discharge (*shown in red line*)



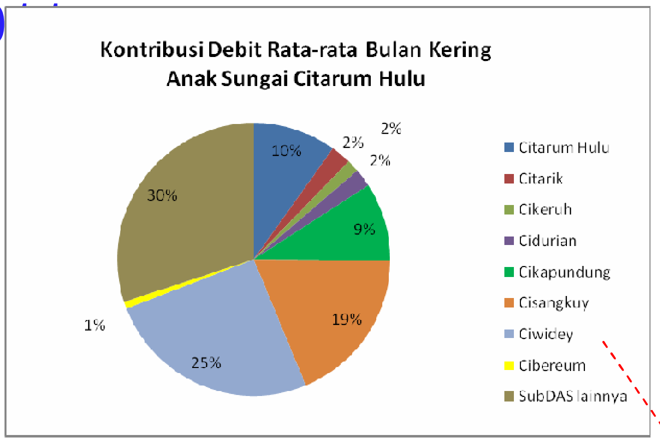
Flood in Upper Part of Citarum River

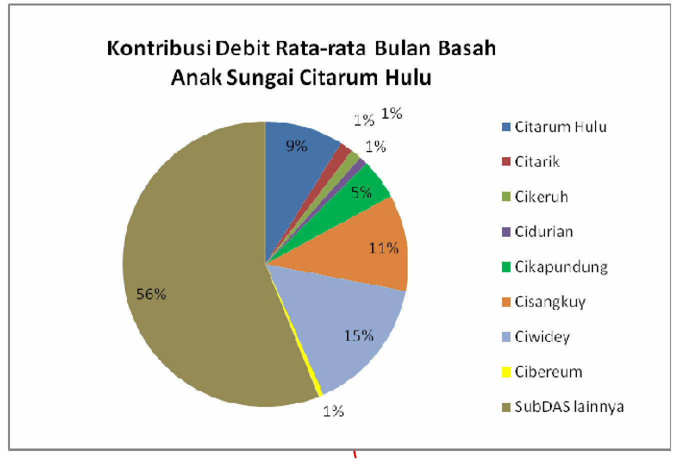
- This figure is flood hydrograph of subwatersheds in Ipper Citarum River in 2001 and 2010
- It is flood hydrograph with maximum rainfall in each subwatershed. They are Upper Citarum subwatershed, Citarik, Cikeruh, Cisangkuy and Cikapundung

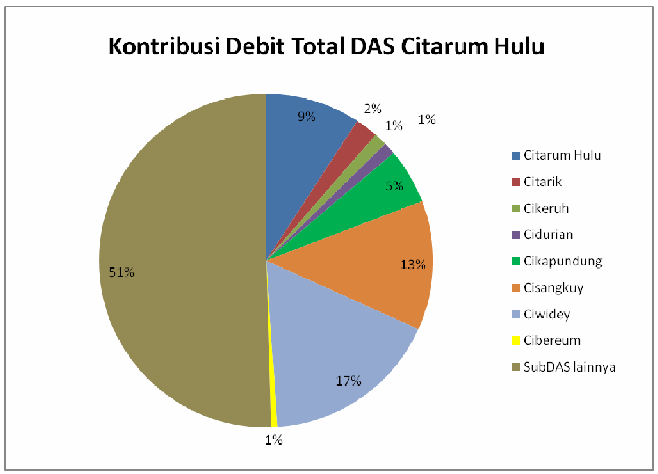




Flood Discharge of Each Tributary Based On Observation Data 2007 s/d 20







Contribution in Wet Season (October – April)

Contribution in Dry Season (May – September)

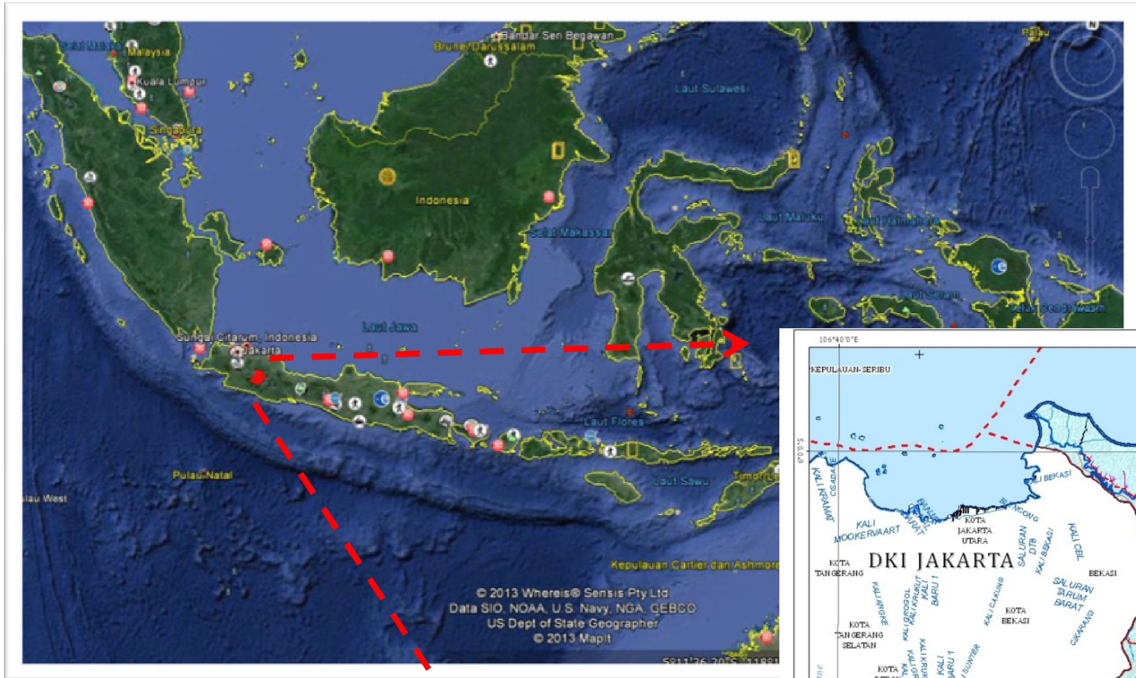
Potensial Contributor :Cisangkuy dnd Ciwidey

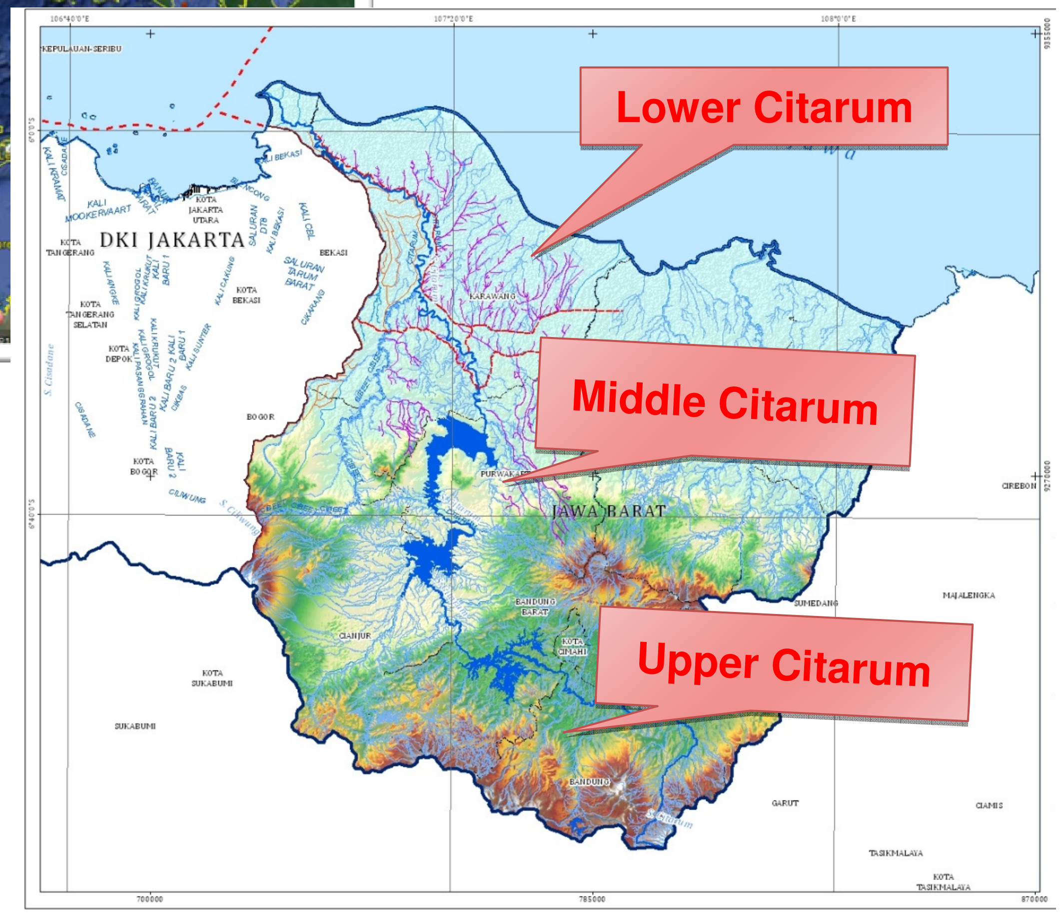
Drought Study in Citarum River

Drought in Citarum River

Sawah kering di Kabupaten Karawang (Cita-citarum)

- Identify the 1980-2009 Citarum River Basin drought
- Spatial drought indices based on simple/common method : Standardized Precipitation Index



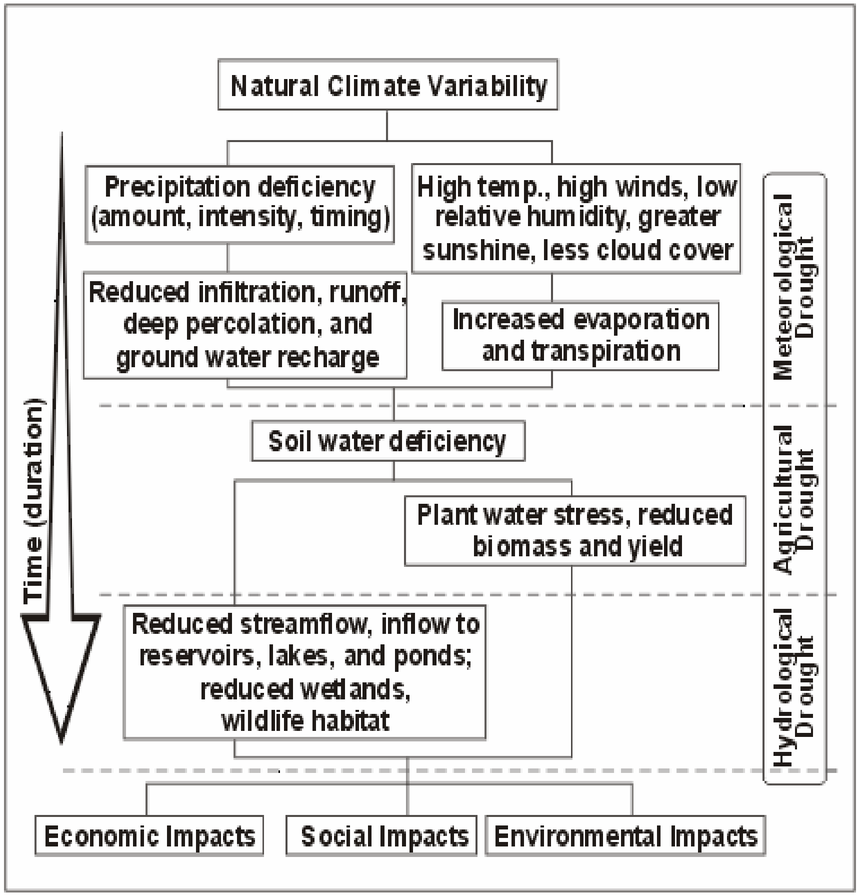


- Longitude: 106 ° 51'36 "- 107 ° 51 'E
- Latitude: 7 ° 19 ' - 6 ° 24' LS
- River length: 297 km
- largearea: 6.614 km ²
- Average discharge: 48 billion m3/year
- The average temperature ranges from 17.4 to 30.7 ° C
- precipitation ranges from 1000-6000 mm
- Consist of 3 DAM ; Saguling (982 million m3), Cirata (2,165 million m3) and Juanda Reservoir (3,000 million m3)
- consists of 2,745 rivers

Citarum River Basin,West Java. *Indonesia*

Recent Activities

2013



Influence of precipitation deficiency and other factors on drought development (National Drought Mitigation Center)

- Meteorological Drought
  - Measured in terms of the degree of dryness (intensity) and the duration of the dry period
  - Region Specific
- Agricultural Drought
  - Meteorological drought that impacts agriculture
  - Usually the first economic sector to be hit
  - Precipitation shortages, ET, soil moisture, etc…
  - Plant water demand versus available soil moisture

Drought Monitoring

- ❑ Curent Criteria Drought intensity which based on the meteorological definition are :
  - Dry: if the rainfall is between 70% - 85% of normal condition (rainfall is below normal condition)
  - very dry: if the rainfall is between 50% - 70% of normal condition (rainfall is far below normal condition)
  - Extremely dry : if the rainfall is < 50% of normal condition (rainfall is very far below normal condition)
- ❑ Choosing appropriate drought index:
  - Basic/common and usefull drought information for agriculture, domestic)
  - Simple and applicable based on the existing data availability
  - SPI Drought Index

Standardized Precipitation Index (SPI)?

- A statistical method for assessing rainfall
- The understanding that a deficit of precipitation has different impact on groundwater, reservoir storage, soil moisture, snowpack and streamflow led to development of SPI (Mckee, Doesken and Kleist, 1993)*
- Most common drought monitoring index
- It is designed to quantify the precipitation deficit for multiple time scales such as 1,3,6,9,12,24 months
- The SPI is a dimensionless index where negative values indicate drought, but positive values show wet conditions.

Table 1. Classification of SPI Value Scale (Source ; BMKG)

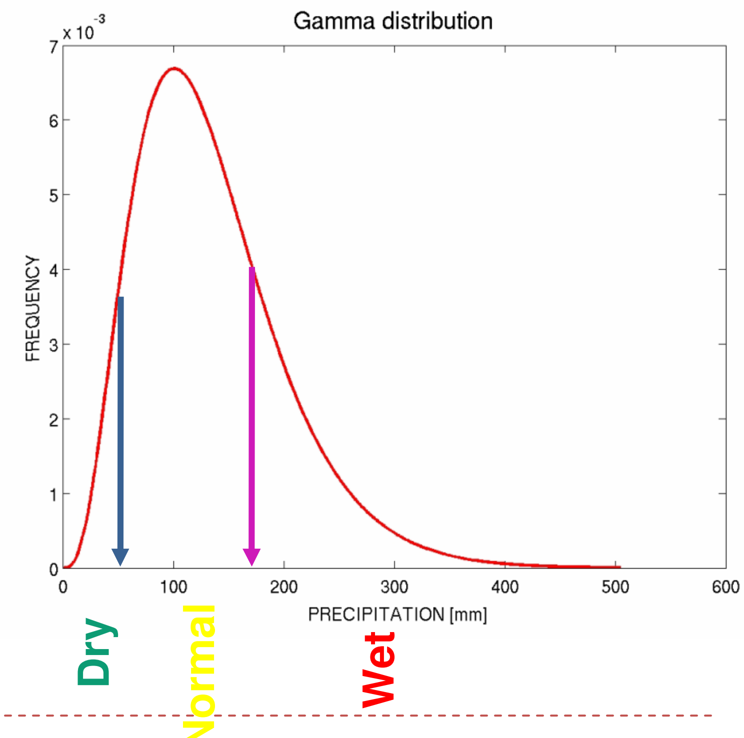
SPI Value	Category
≥ 2.00	Very wet
1.50 ~ 1.99	Wet
1.00 ~ 1.49	Moderately wet
-0.99 ~ 0.99	Normal
-1.00 ~ -1.49	Moderate Drought
-1.50 ~ -1.99	Drought
≥ -2.00	Extremely Drought

The Calculation of SPI

- Simulated with long time period used 30 years or more
- Thom (1966) -> Gamma distribution fits precipitation sums well

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)_0} x^{\alpha-1} e^{-x/\beta} dx$$

$\alpha > 0$	α is a shape parameter
$\beta > 0$	β is a scale parameter
$x > 0$	x is the precipitation amount
$\Gamma(\alpha) = \int_0^{\infty} y^{\alpha-1} e^{-y} dy$	$\Gamma(\alpha)$ is the gamma function



SPI procedure:

1. Parameter estimation for Gamma distribution (based on least square method) frequency distribution of precipitation sums for station
2. Parameters of Gamma distribution are determined for each station and time scale of interest (1 month, 2 months, ...)
3. Thom (1966) determined parameters based on maximum likelihood method:

$$\alpha = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right) \qquad \beta = \frac{\bar{x}}{\alpha}$$

Where ;

$$A = \ln(\bar{x}) - \frac{\sum \ln(x)}{n}$$

n = Summary of Rainfall data

- Estimated parameters are then used for calculating cumulative probability distribution for a specific precipitation event, which has been observed on a defined time scale (e.g. month):

$$G(x) = \int_0^x g(x)dx = \frac{1}{\beta^{\alpha}\Gamma(\alpha)_0}\int_0^x x^{\alpha-1} e^{-x/\beta} dx$$

- Gamma function is not defined at x=0 (but there is large number of no rainfall occurences as we move to shorter time scales); cumulative distribution is therefore modified to include these events:

$$H(x) = q + (1-q)G(x)$$

where q is the probability of no rainfall on specified time scale

Transformtion of cumulative probability distribution H(x) into standardized normal distribution (Abramowitz in Stegun, 1965)

$$SPI \; untuk \; 0 < G(x) \leq 0.5$$

$$z = SPI = -\left(t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right)$$

Where :

$$t = \sqrt{\ln\left(\frac{1}{(H(x))^2}\right)}$$

$$dan \; SPI \; untuk \; 0.5 < G(x) \leq 1$$

$$z = SPI = 1\left(t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right)$$

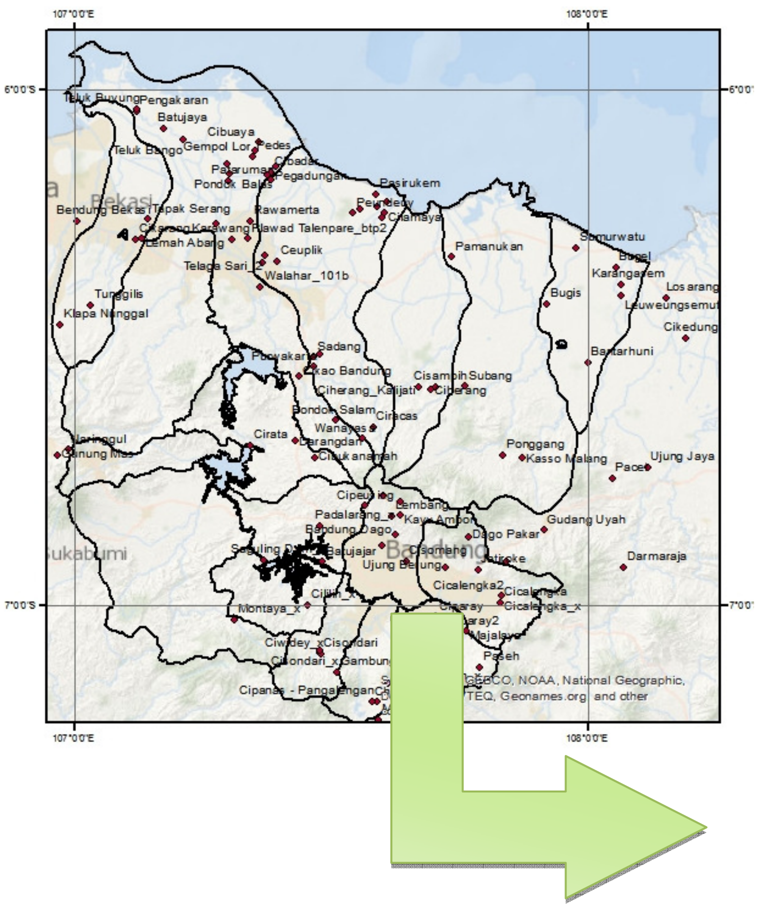
Where :

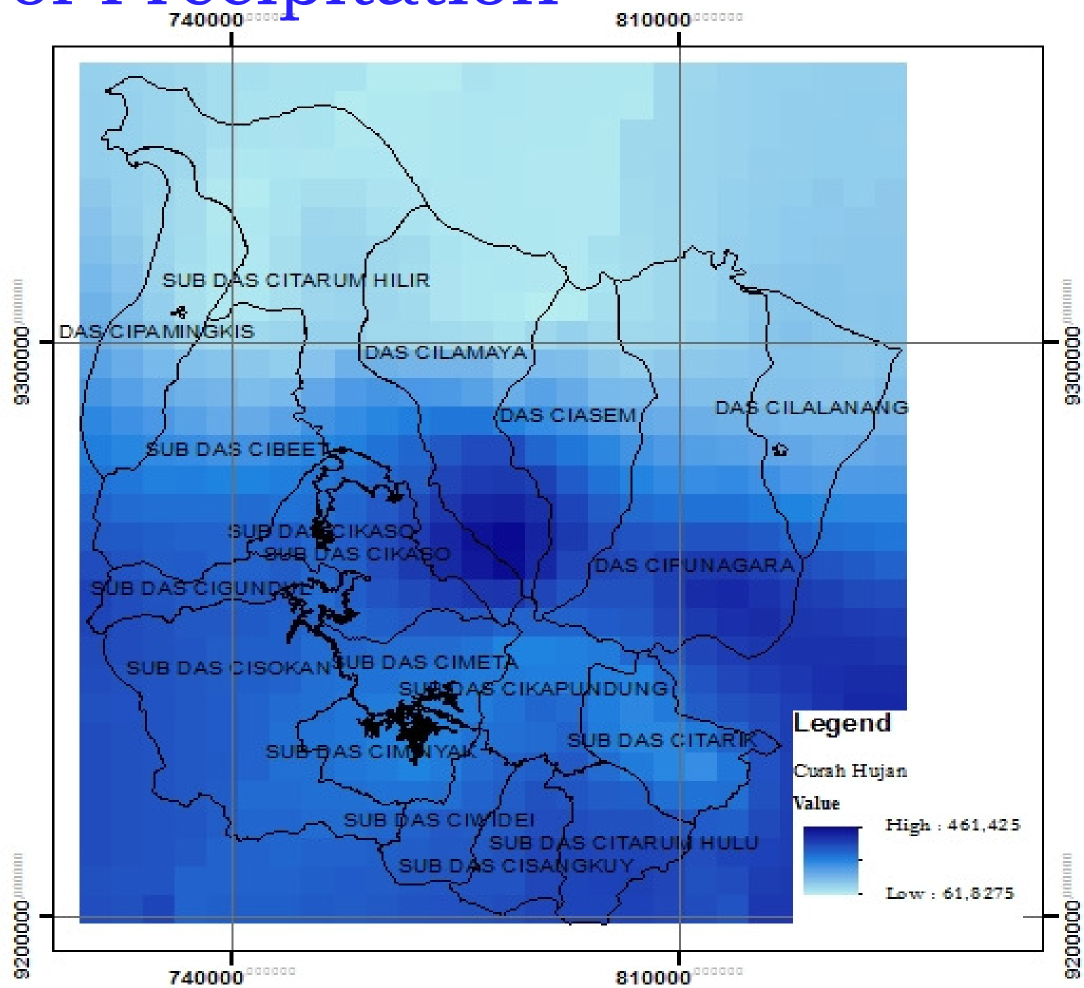
$$t = \sqrt{\ln\left(\frac{1}{(1 - H(x))^2}\right)}$$

And:

c_0 = 2,515517
c_1 = 0,802853
c_2 = 0,010328
d_1 = 1,432788
d_2 = 0,189269
d_3 = 0,001308

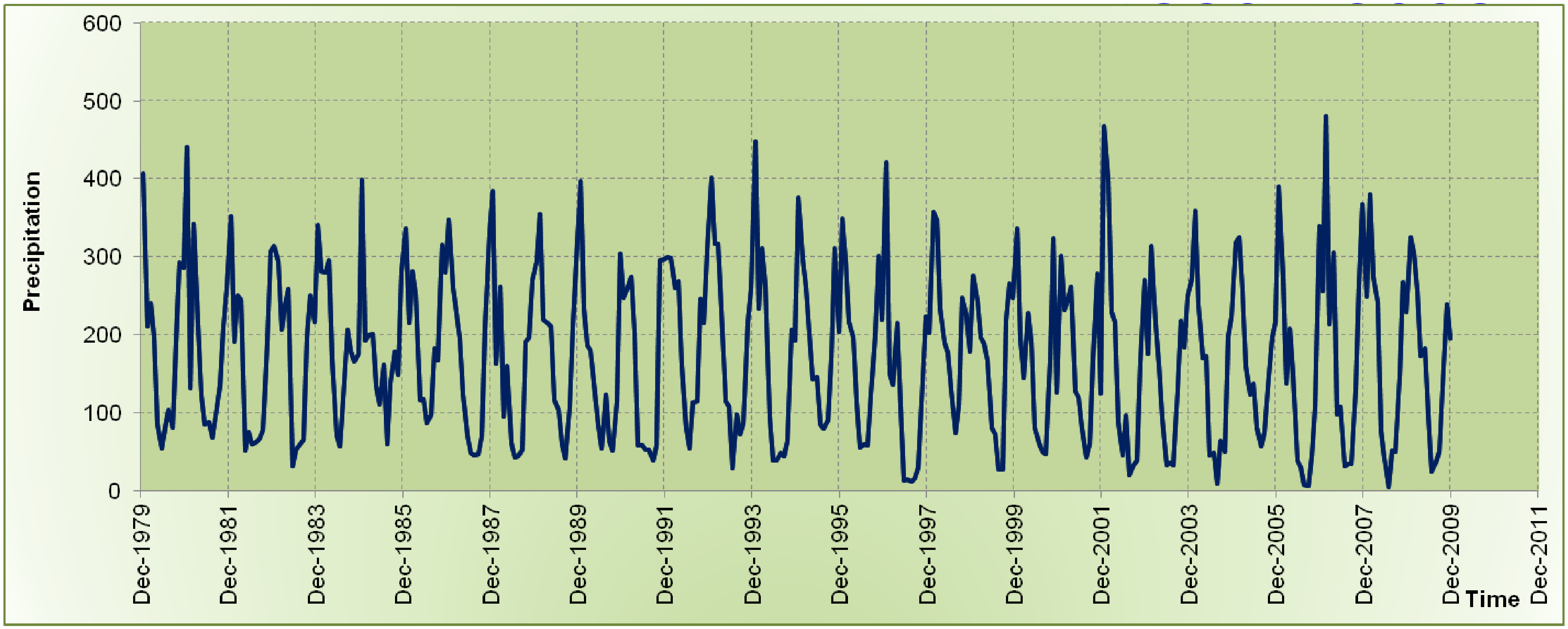
Spatial Distribution of Precipitation





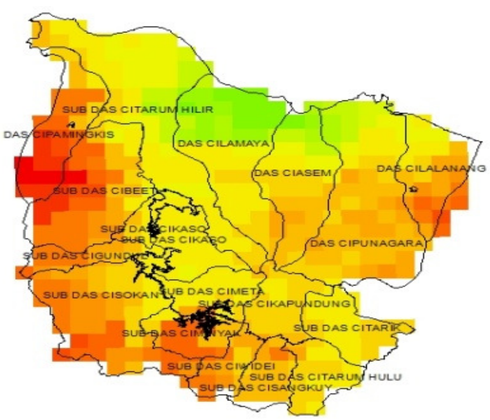
▶ Kusuma, MSB, et.al, Water Res Eng, FCEE, ITB

Average Precipitation in Citarum River Basin



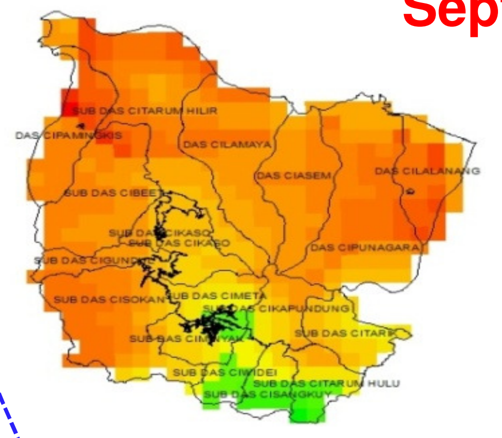
Recent Activities

February

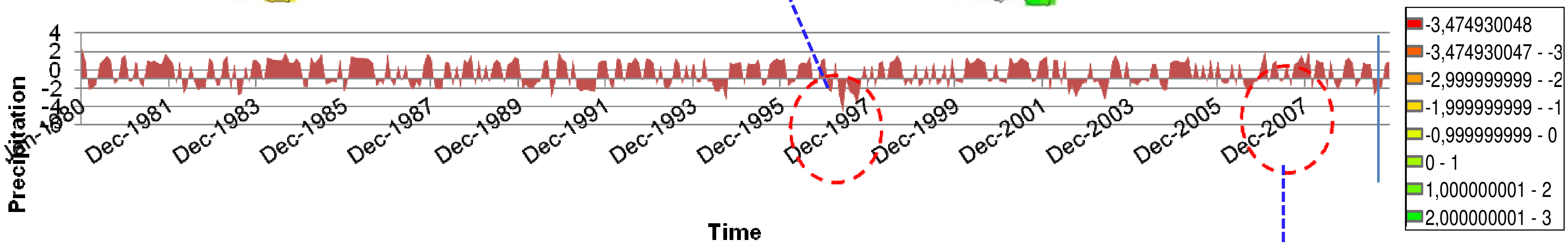


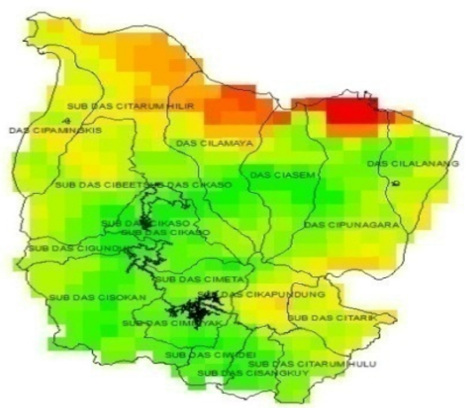
1997
- SPI : -1.5 to -2
- Moderate - Severe drought .

September

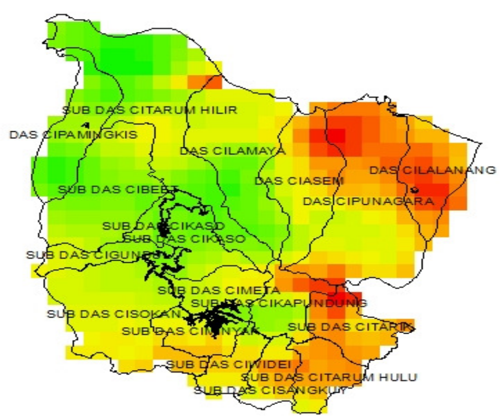


1997
- SPI i ≥ -2
- Extremely drought for all areas
- September is recorded as the worst drought.





2007
Normal - moderately wet.



2007
Partially drought
Less drought than that of Wet season in 1997

Policy and Implementation

Current and Future short and medium term program

- Continuing Citarum Study and other climate change related on going Program
- Further step of new undergraduate program
  - International network/cooperation for education program
  - Improving proposed curricullae
  - Fist year of undergraduate running program 2014.
- Following up potential cooperation.

Thank You