GEOSS Asian Water Cycle Initiative

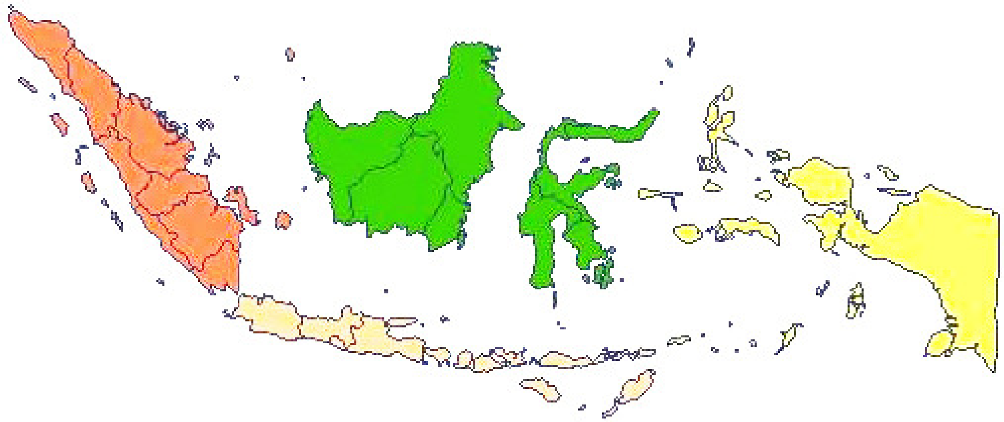
Country Activities

INDONESIA

Preparedness Effort toward Climate Change Adaptation

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

- INDONESIA is an archipelagic country consisting of 17.500 islands located in South East Asia.



- Population: 237.424.363 (2011 census)

  Climate: Tropical rainforest

  Average annual rainfall: Min = 1000 mm/year (Sumbawa)

  Max = 13000 mm/year (Irian Jaya)

  Ave = 2000 – 4000 mm/year (BMG)

CLIMATE CHANGE Disaster

- Main disastrous events are **flood** and **drought**.
- **Flood** (related to excess rainfall) may create disasters:
  - Inundation in populated area (damages the buildings and disrupts social activities)
  - Dam break caused by overflowing (triggers small tsunami-like flood that destroy its downstream)
- **Drought** (related to deficient rainfall) may disasters:
  - Water supply shortage (lead to fail harvest)
  - Fires in tropical rainforest (produce high carbon emission)

CLIMATE CHANGE Adaptation

- Indonesia is a country with high risk of flood and drought hazard. **Climate change** might lead to the **increase of intensity and potential risk** of these hazards in Indonesia
- **Reduction of disaster risk** is done by preparedness effort.
- **Preparedness effort goal** is capacity building to improve climate change adaptation.
- **Preparedness effort activities** are categorized into 2 types:
  - **Structural**: engineering, infrastructure construction/development
  - **Non-structural**: network development, education/training and funding support.
- **Structural effort** aims in improving infrastructure's capacity (ex: channel dredging).

PREPAREDNESS Effort

- Climate change adaptation program in Indonesia is conducted both through **structural** and **non-structural** effort.
- Non-structural effort is needed to support the long-term development of structural effort, and conducted through various activities, e.g.:
  - increasing people awareness and capacity development
  - developing methodology for hazard risk assessment
  - preparing qualified human resources in water resources,
  - development of hydrological database
  - development of early warning system

NON-STRUCTURAL Activities

These activities and partnerships are some of the current examples:

Network Development

- Data Base Development : GOI (Government Of Indonesia, cq PU, BMKG, local govt, BAKOSURTANAL etc), AWCI-Tokyo Univ., K-Water, CKNet
- Research : Hiroshima Univ., Tohoku Univ., Kouchi Univ.
- Association : AWCI, GEOSS, HATHI, MHI

Education / Training

- Updating curricula of Master Study Program on Water Resources Engineering
- Establishment of Water Resources Engineering for engineer/bachelor degree
- Exchange program for faculty member and student : Erfurt Univ., Pitsburg Univ, Hiroshima Univ., Tohoku Univ., Kochi Univ
- GOI : Ministry of Public works, Ministry of Environment and Local Government

Funding Support

- National : DGHE (Directorat General of Higher Education): providing research funding and higher-education scholarship for Indonesian students
- International : USAID and ADPC (PROMISE : awareness against flood in Jakarta), Asahi Glass Foundation (Flood Early Warning System), JICA (Physical Model Laboratory)
- Etc.

RESEARCH Activities

Research activities play part in developing analysis method and warning system to support climate change adaptation.

- Rainfall Data Analysis in Citarum River Basin
  - Analyzing the importance of database to study historical climate behavior (rainfall, discharge, etc)
- Flood Control Study in Bandung Regency
  - Developing method to analyze flood control solution
- Urban Flood Inundation in Jakarta
  - Developing method to model flood inundation for warning system
- Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model
  - Developing method to analyze forest fire risk

RESEARCH: Rainfall Data Analysis in Citarum River Basin (1)

BACKGROUND

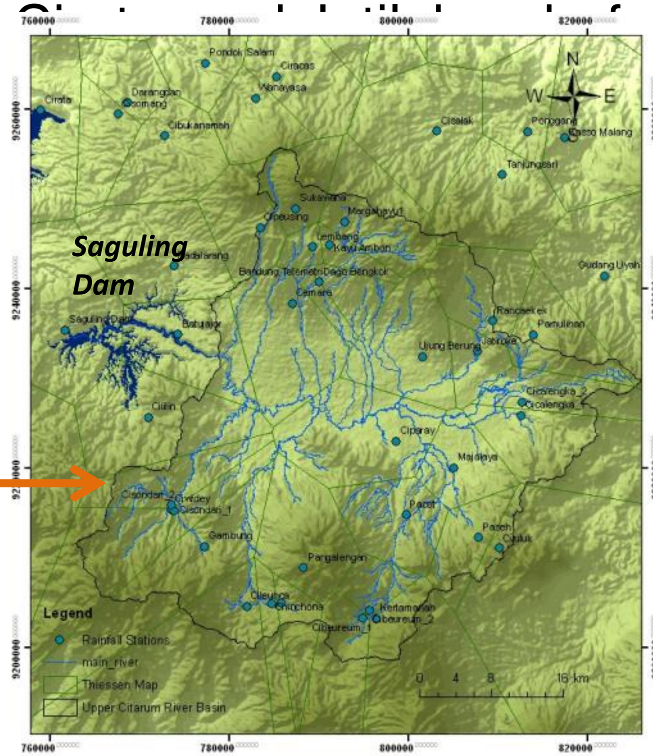
- **Flood disaster** often occurs during rainy season around the Citarum River which flows through Bandung Regency.
- **Lack of water supply** from Upper Citarum River Basin during dry season might disturb water supply for irrigation.
- These problems are associated with **climate change impacts** .
- The climate change adaptation effort have to deals with **common constraints** in Indonesia:
  - 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 the constraints for Climate Change adaptation effort in the future.

RESEARCH: Rainfall Data Analysis in Citarum River Basin (2)

STUDY AREA

- **Citarum River Basin** is one of the strategic Basins in West Java, Indonesia.
- **Citarum River** flows from the mountainous area in Bandung, through the 3 cascade dams: Saguling, … e finally fl…

Citarum River Basin



Upper Citarum River Basin

RESEARCH: Rainfall Data Analysis in Citarum River Basin (3)

Current Condition in Upper Citarum River Basin:

1) Flood in Upper Citarum River Basin

- Overflow of the Citarum River in Dayeuh Kolot Subdistrict is caused by high rainfall intensity and inadequate channel capacity.
- Inundation in Dayeuh Kolot Subdistrict is hard to be drained because of its lowland condition.
- This inundation would bring mud and damage properties.

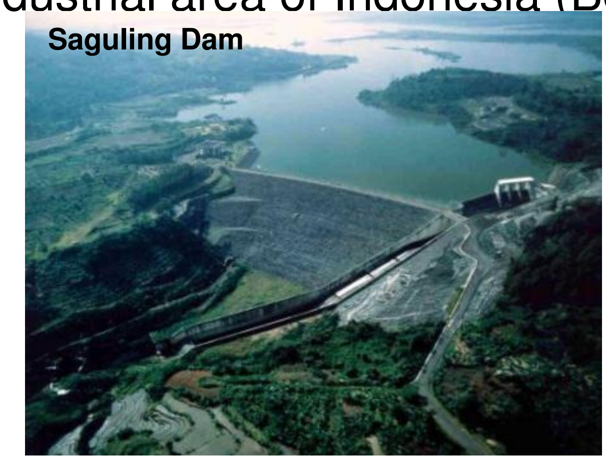

Source: Natasaputra, 2010.

RESEARCH: Rainfall Data Analysis in Citarum River Basin (4)

Current Condition in Upper Citarum River Basin:

2) Upper Citarum River as Source of Water for Agriculture Area

- The average inflow to Saguling Reservoir in 2010 was 85.6m3/s, while inflow to Cirata and Jatiluhur Reservoirs were 161.2m3/s and 174.1m3/s, respectively.
- Upper Citarum River Basin is the main water supply contributor (49% inflow of Jatiluhur) for drinking water of Jakarta (capital city) and the most developed industrial area of Indonesia (Bekasi, Kerawang and Cikarang).



Source: PJT-II

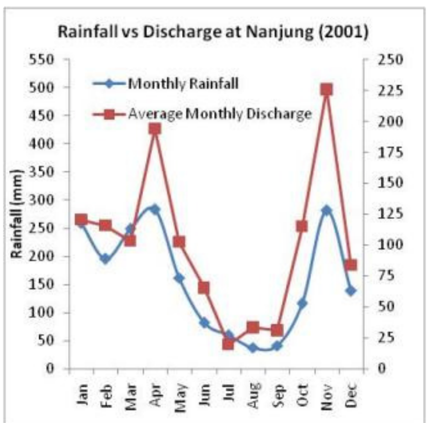
RESEARCH: Rainfall Data Analysis in Citarum River Basin (5)

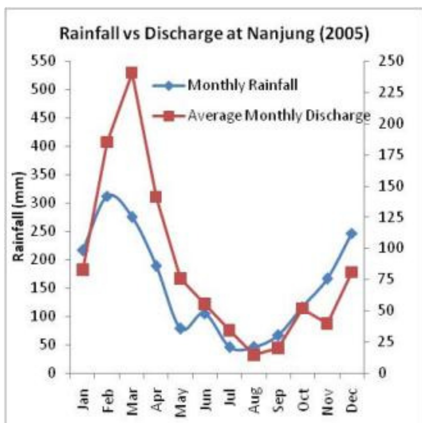
Current Condition in Upper Citarum River Basin:

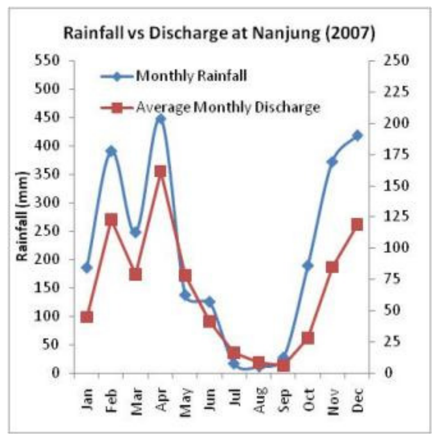
3) Rainfall Runoff Characteristic in Citarum River Basin

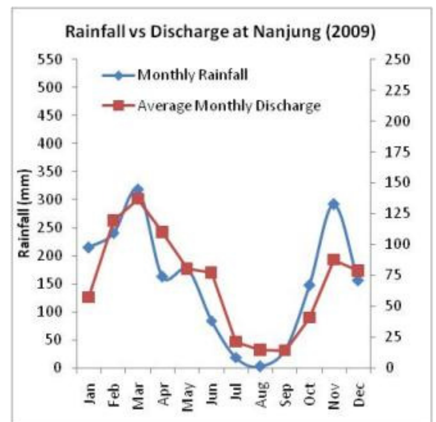
- Rainfall and discharge variability analysis in Upper Citarum River Basin (CRB) is done by comparing discharge stations data in Nanjung (near Saguling Dam inlet) with rainfall area in upper CRB.

- 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.





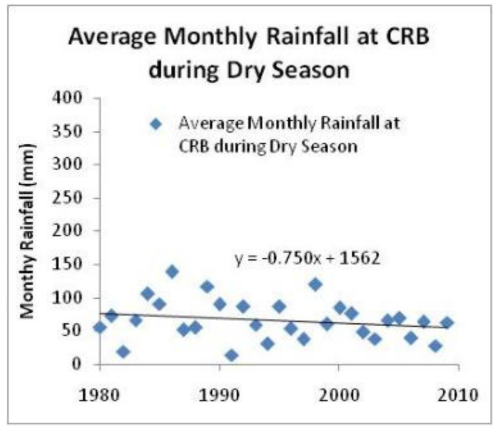


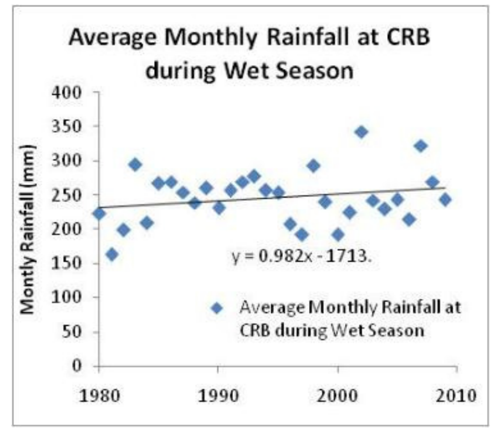


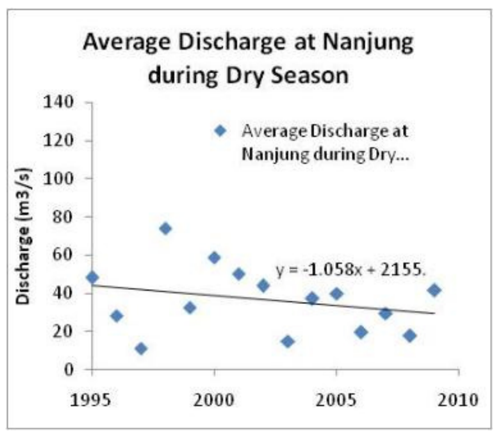
Current Condition in Upper Citarum River Basin:

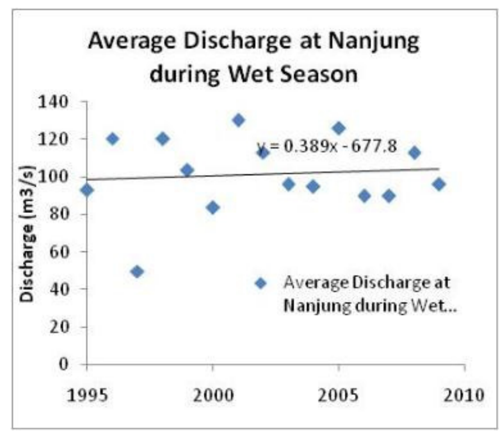
4) Seasonal Rainfall and Discharge Characteristic

- Average rainfall and discharge during wet season tends to increase.
- Average rainfall and discharge during dry season tends to decrease.







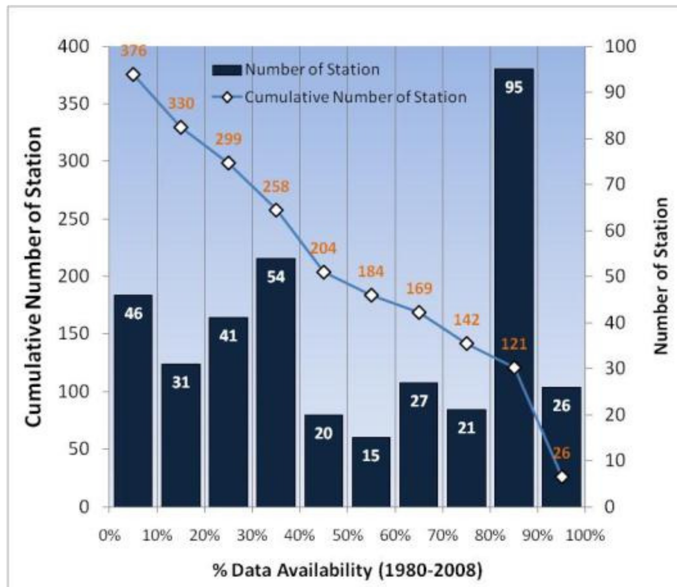


RESEARCH: Rainfall Data Analysis in Citarum River Basin (7)

Current Condition in Upper Citarum River Basin:

5) Hydrological Data Availability

- Analysis from 376 rainfall stations in Citarum River Basin from different data sources for the period of 1980-2008 shows that:
  - Only 26 stations (6.9% of the total rainfall stations) consist of very good data record with data availability more than 90%
  - 142 stations (37.8% of the total rainfall stations) consist of relatively good data records with data availability more 70%
  - 192 stations (51.2% of the total rainfall stations) consist of data records with data availability less than 50%

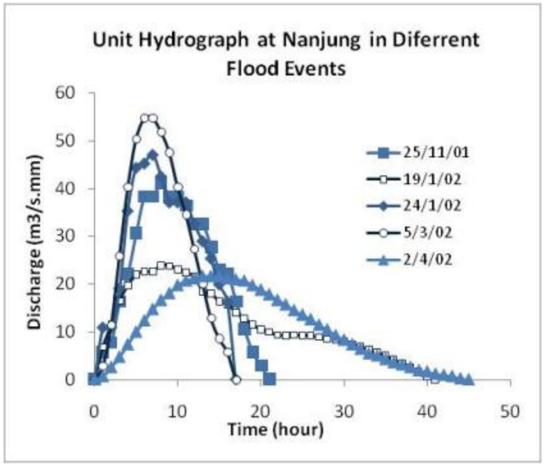


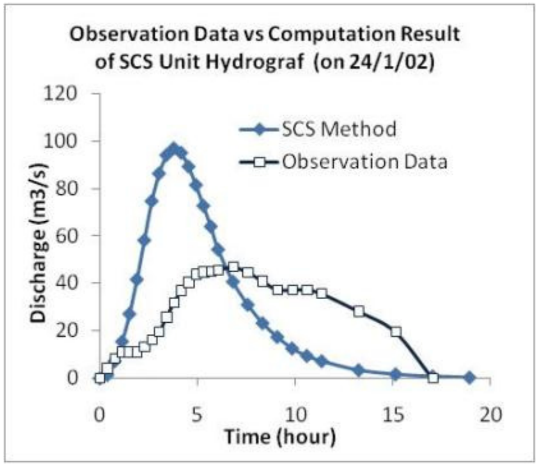
RESEARCH: Rainfall Data Analysis in Citarum River Basin (8)

Current Condition in Upper Citarum River Basin:

6) Hydrology Computation Method

- Most of hydrological computation/method for drainage/flood analysis used in Indonesia was derived in other countries, such as United States and Japan.
- Only few method were derived based on the actual local/regional conditions in Indonesia (might result in discrepancy between computation result and the actual field condition)
- Example of data plot of flood hydrograph based on case study of Nanjung





RESEARCH: Rainfall Data Analysis in Citarum River Basin (9)

Current Condition in Upper Citarum River Basin:

7) Inadequate Water Infrastructures

- Water infrastructure in the downstream of Jatiluhur previously was developed mainly to support irrigation system.
- Rapid land use change during the last decades has resulted in decrease of irrigation area and increase of urban/developed area.
- Irrigation water demand tends to decrease as affected by land use change, while irrigation infrastructures capacity is still in the same.
- This condition might result in the decreasing of water supply efficiency especially during dry season.

RESEARCH: Rainfall Data Analysis in Citarum River Basin (10)

Conclusions (1)

- Upper Citarum River Basin tends to have higher discharge in wet season and lower discharge in dry season in recent year compared to 10 to 15 years ago.
- Change in Upper Citarum River Basin condition is not only affected by anthropogenic factor (land cover change, urban area development), but also affected by changes in climate conditions.
- Plot of rainfall data also shows that average monthly rainfall data in wet season tends to increase, while average monthly rainfall data in dry season tends to decrease.

RESEARCH: Rainfall Data Analysis in Citarum River Basin (11)

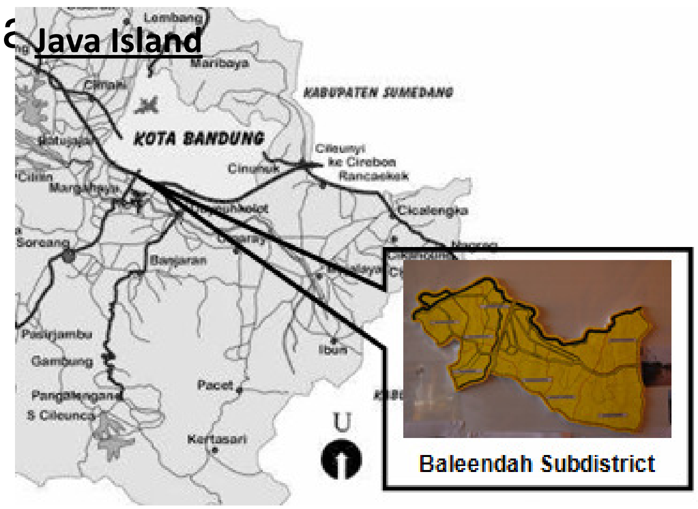
Conclusions (1I)

- Lack of hydrological data availability and undeveloped hydrological computational method in Indonesia hint that the preparedness of Upper Citarum River Basin on Climate Change adaptation effort is still far from ideal conditions.
- Further improvement needs to be accomplished for future Climate Change adaptation effort in Upper Citarum River Basin, which might be caused by natural, anthropogenic, and combination between the two causes.
- The improvements are crucial in the sectors of data acquisition, data sharing, management, and the development of more reliable hydrological computation and modeling method.
- These improvements can be achieved by conducting activities and partnership with local and international organizations.

RESEARCH: Flood Control Study in Bandung Regency (1)

Background

- Citarum River, which flows through Bandung Regency, has been affected by climate change in the occurrence of heavy flood disaster in recent years.
- Heavy flood disaster in particular occurs in Baleendah Sub-district, a low a r which is densely-populated.



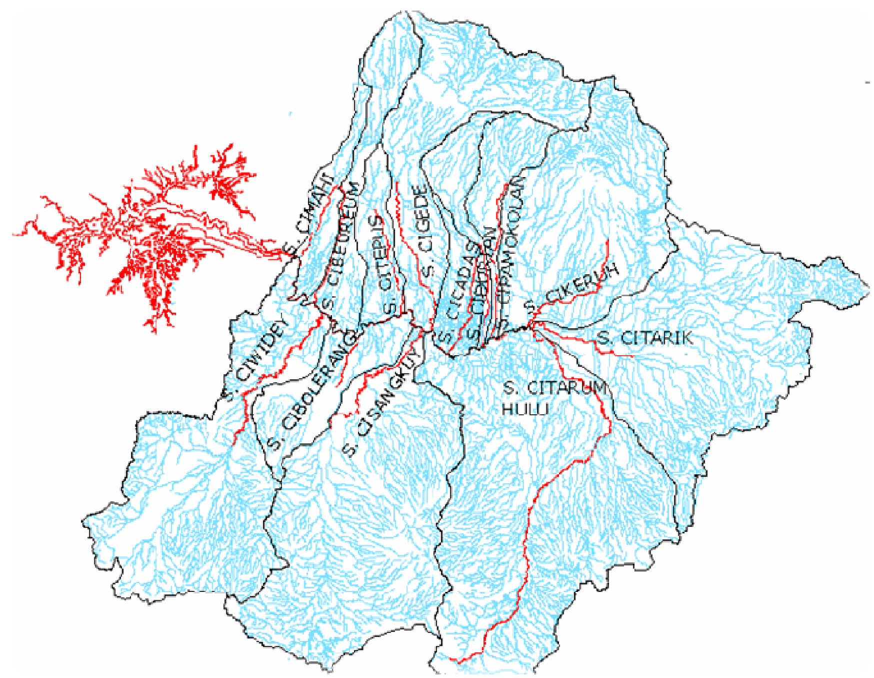
- Previous solutions such as channel dredging and building dikes have become insufficient, which requires further study to find other alternatives.

RESEARCH: Flood Control Study in Bandung Regency (2)

Objective

- This study aims in providing alternate solution to flood problem in Bandung Regency, by analyzing all 13 sub-basins of Citarum River which becomes the source of flooding.
  - The result is expected to identify the sub-basin which mainly contributes the flood discharge of Citarum River.
  - Flood control measurements can be prioritized on the problematic sub-basin to minimize flood discharge load to Citarum River.

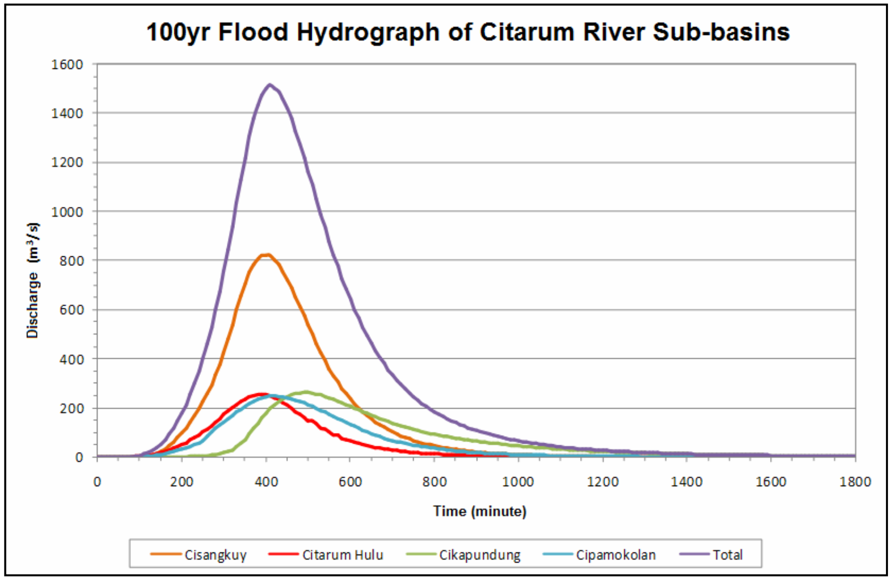
Upper Citarum River Sub-Basin Network



RESEARCH: Flood Control Study in Bandung Regency (3)

Flood Hydrograph Modeling

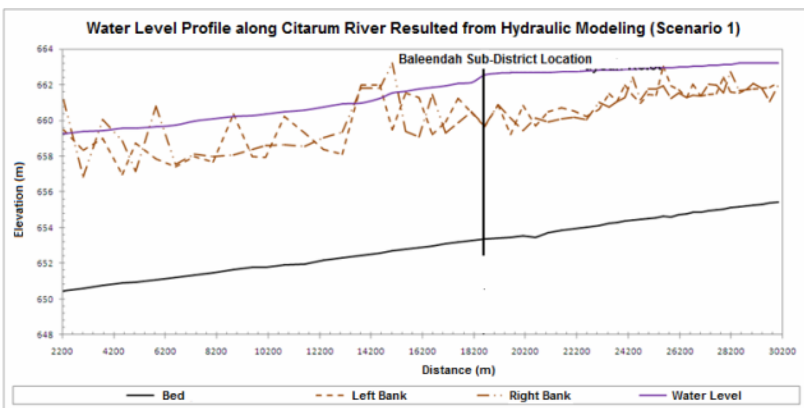
- 100 yrs flood hydrograph is obtained using basin modeling with HEC-1 for each sub-basin. Initial modeling includes 4 sub-basins which are Cisangkuy, Citarum Hulu, Cikapundung and Cipamokolan
- Input parameters include:
  - 100 yrs regional rainfall
  - Sub-basin characteristics: topography, land use and land cover as Digital Elevation Model (DEM) downloaded from Consultative Group on International Agricultural Research – The Consortium for Spatial Information (CGIAR-CSI) website.
  - Flood routing method (Muskingum Cunge which has been widely applied and mostly gives good/accurate results)

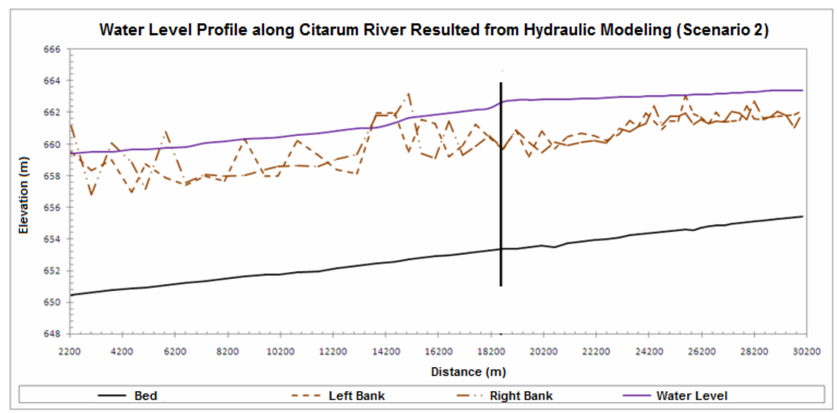


RESEARCH: Flood Control Study in Bandung Regency (4)

Hydraulic Modeling

- 1D flow modeling with HEC-RAS is done to identify overflow potential along Citarum River when it is flowed with flood hydrograph from the four studied sub-basins.
- There are 2 modeling scenarios:
  1) Simultaneous rainfall occurance on all four sub-basins. In this scenario all flood hydrographs are inputted at the same time.
  2) Extreme condition in which the peak discharge of four flood hydrographs simultaneously enter Citarum River.





RESEARCH: Flood Control Study in Bandung Regency (5)

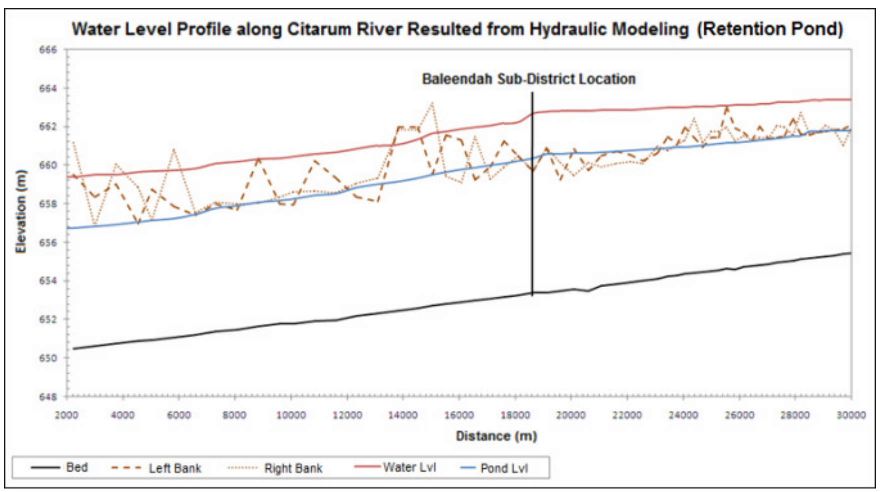
Flood Control Analysis

- The results of modeled hydrograph (of initial 4 sub-basins modeling) show that Cisangkuy gives the highest flood discharge contribution to Citarum River.
- Flood control analysis to reduce discharge contribution of Cisangkuy Sub-basin is planned as retention pond.
- Considerations for choosing retention pond:
  - Capable of temporarily storing flood discharge from the sub-basin to delay it entering Citarum River.
  - Capable of controlling hydrograph outflow to Citarum River to avoid simultaneous peak time of all hydrograph.

RESEARCH: Flood Control Study in Bandung Regency (6)

Flood Control Result

- Required retention pond dimension is obtained with HEC-HMS modeling which produces flood hydrograph of Cisangkuy Sub-basin that has lower value than the initial result (without retention pond).
- The reduced Cisangkuy flood hydrograph is modeled again in HEC-RAS. The result shows flood HWL reduction in Citarum River, in which overflow still occurs but in minor state.



RESEARCH: Urban Flood Inundation in Jakarta (1)

Background

- Urban flood has been an enormous problem for many cities in the world.
- Appropriate model for urban flood prediction is necessary in order to support decision maker in urban planning.
- Flood in urban area has different characteristic compare to flood in rural area.
- Developed model should consider physical based process in order to represent natural phenomena of urban flood

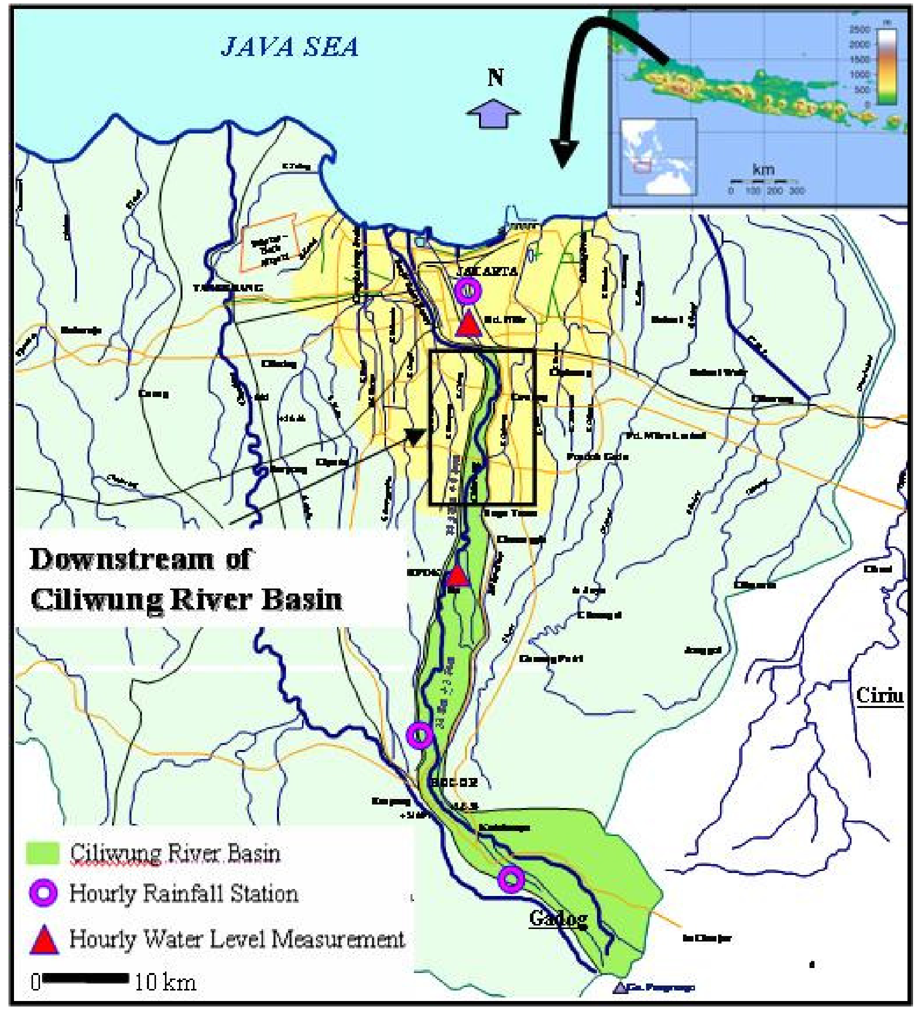
RESEARCH: Urban Flood Inundation in Jakarta (2)

Objective

- To develop integrated urban flood model with rainfall-runoff process in dense building area considering physical based process.

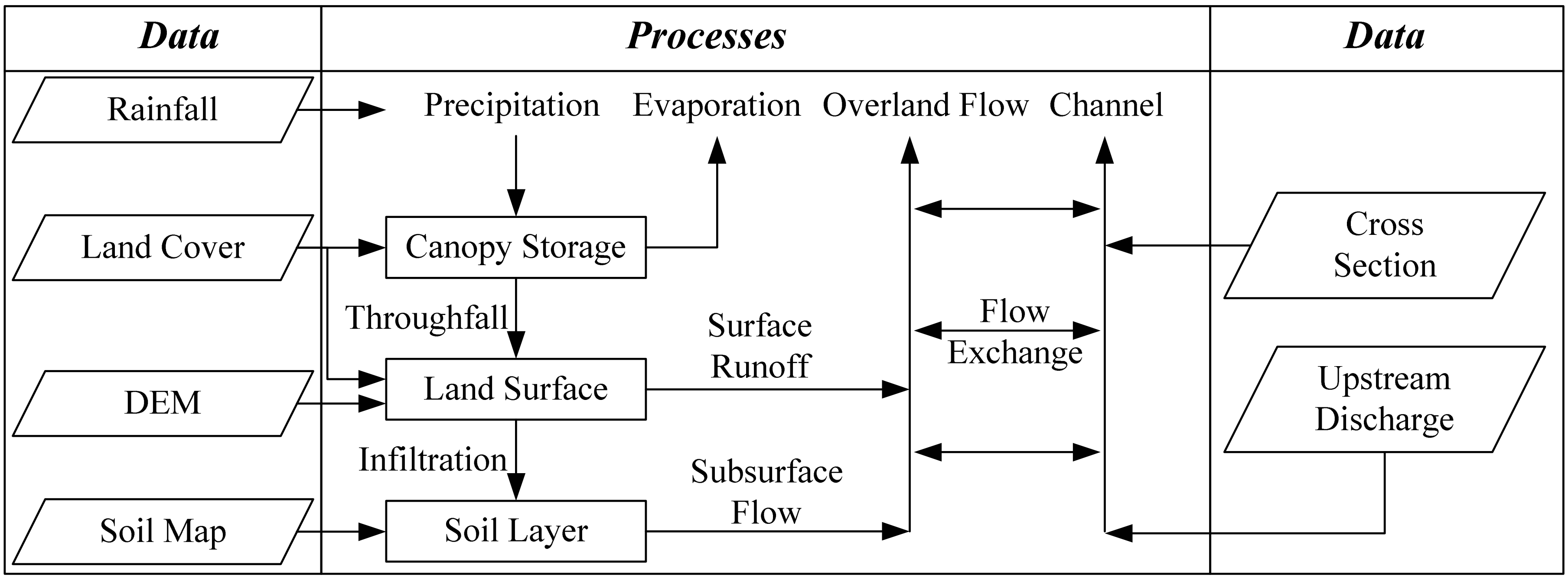
Study Area

- Downstream part of the Ciliwung River basin in Jakarta, West Java, Indonesia.
- 38 km2 of catchment area and 20 km of river length.
- Located around central activities in area with high density of building.



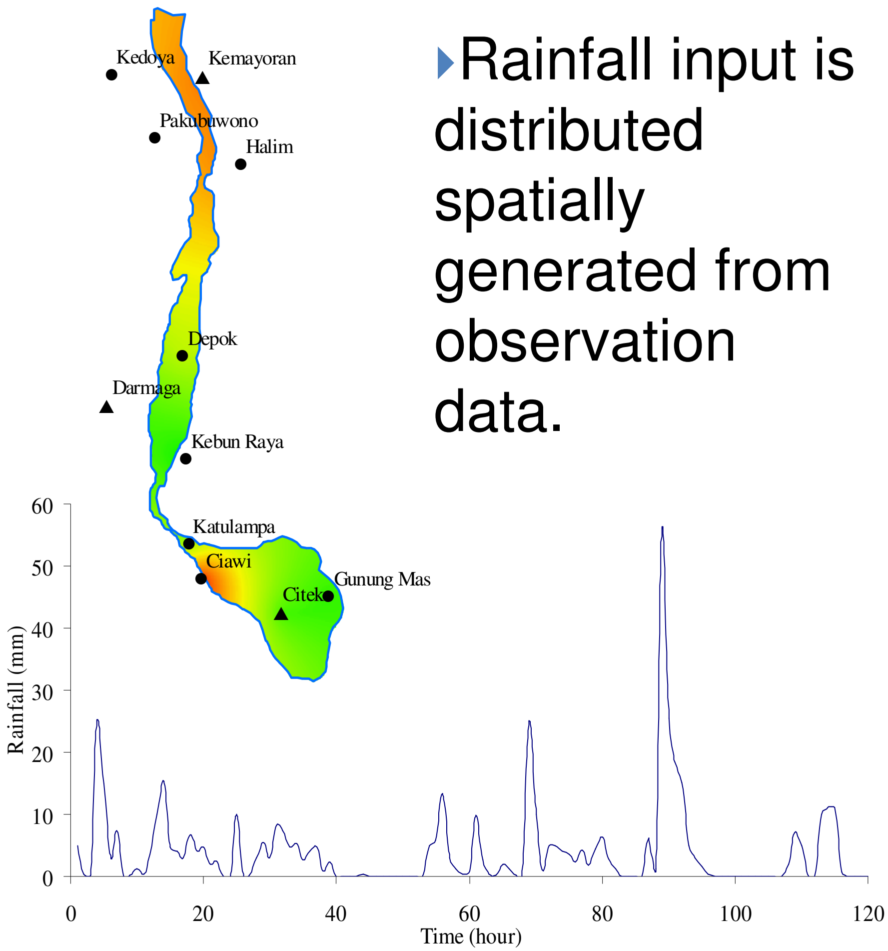
RESEARCH: Urban Flood Inundation in Jakarta (3)

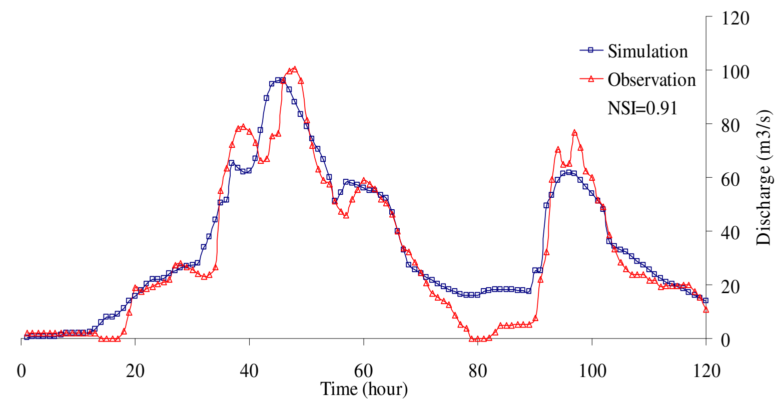
Model Development



Model Scenario

- Rainfall input is distributed spatially generated from observation data.
- Discharge input is generated from upstream model output which has been verified with observed data.

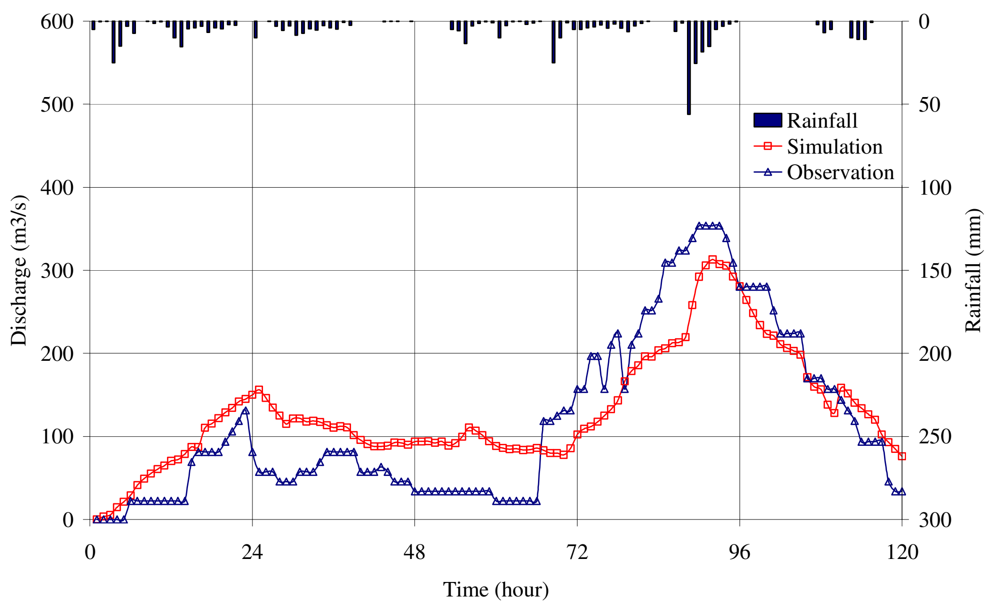


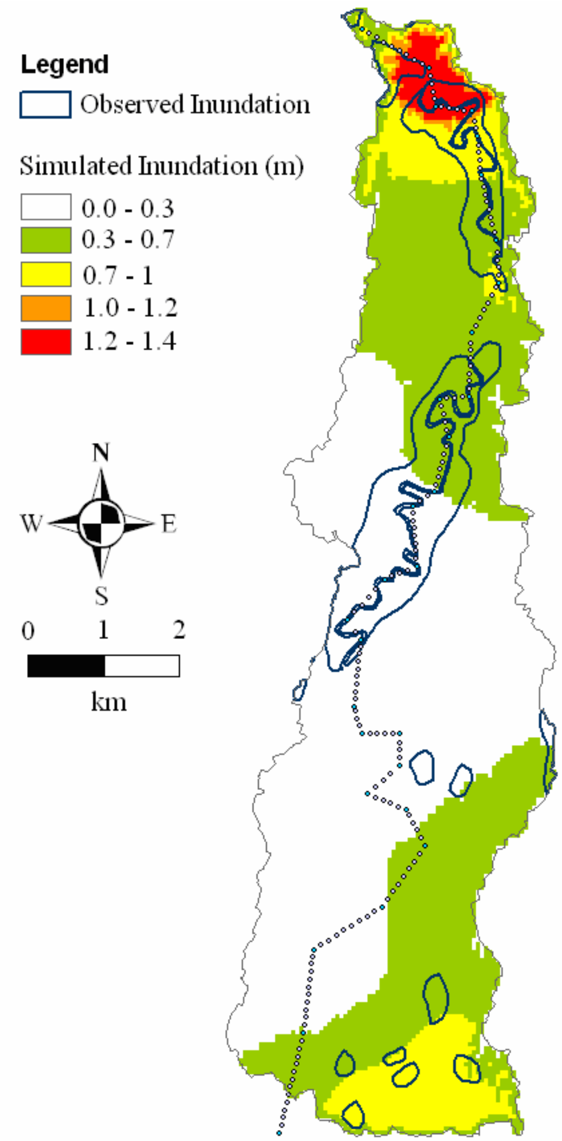


RESEARCH: Urban Flood Inundation in Jakarta (5)

Model Result

- Good agreement is shown by comparison to observed data with high value of Nash Sutcliffe Index of 0.75.





Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model (1)

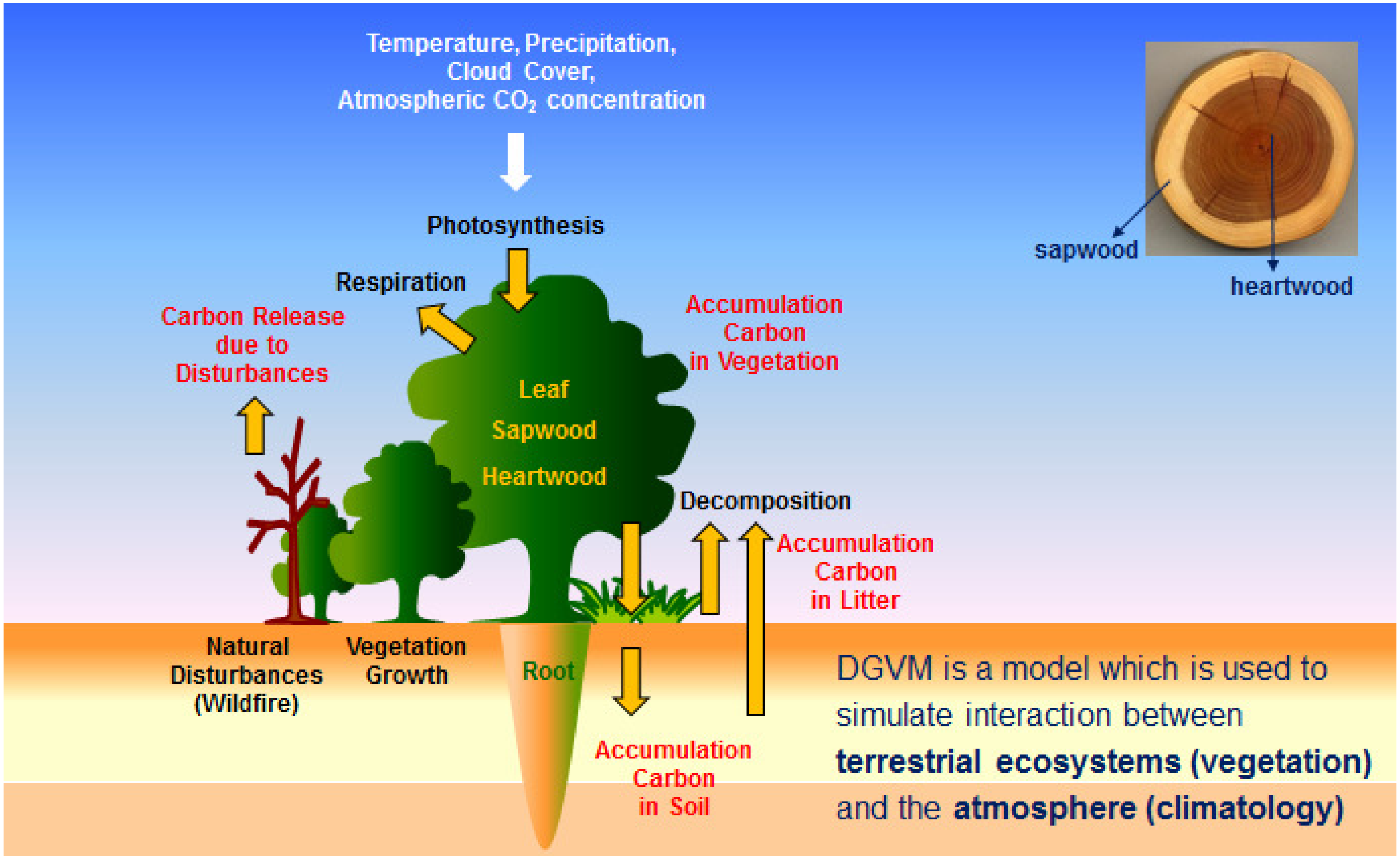
Background

- During 1997/1998 forest fire, from about 8.1 million ha area affected by fire in Kalimantan, 1.1 million ha (13.5%) was in peat and swamp forest (Tacconi et al, 2007).
- Total carbon released to atmosphere during 1997/1998 forest fire in Indonesia was estimated between 0.81 to 2.57 GtC, 78% resulted from peat combustion (Page et al., 2002)
- **Climate change might lead to the increase of drought intensity** which result in lower water table in peatland, and intensifies peat decomposition, removing 40% to 86% soil organic carbon in the next 100 years (Ise et al, 2008)
- In this study, the **effect of climate change to drought and variation of soil water level** was simulated by using LPJ-DGVM to estimate the occurrence of forest fire in Kalimantan.

Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model (2)

Objective and Methodology

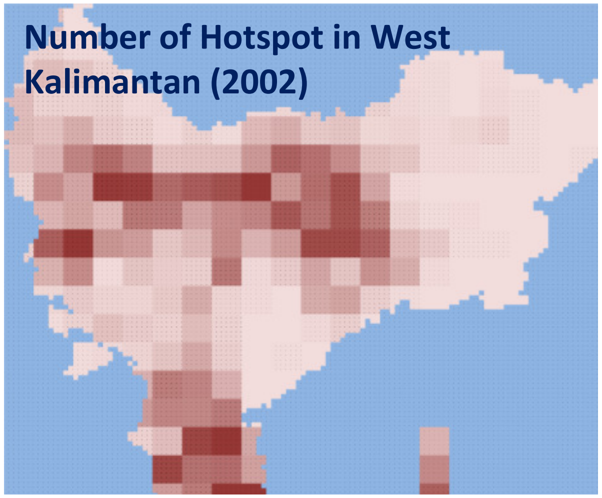
Lund University PIK Max-Planck-Institut für Biogeochemie MPI-BGC Jena

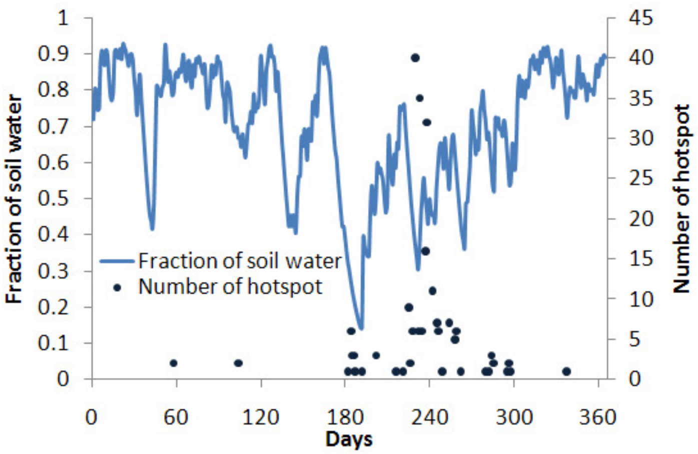


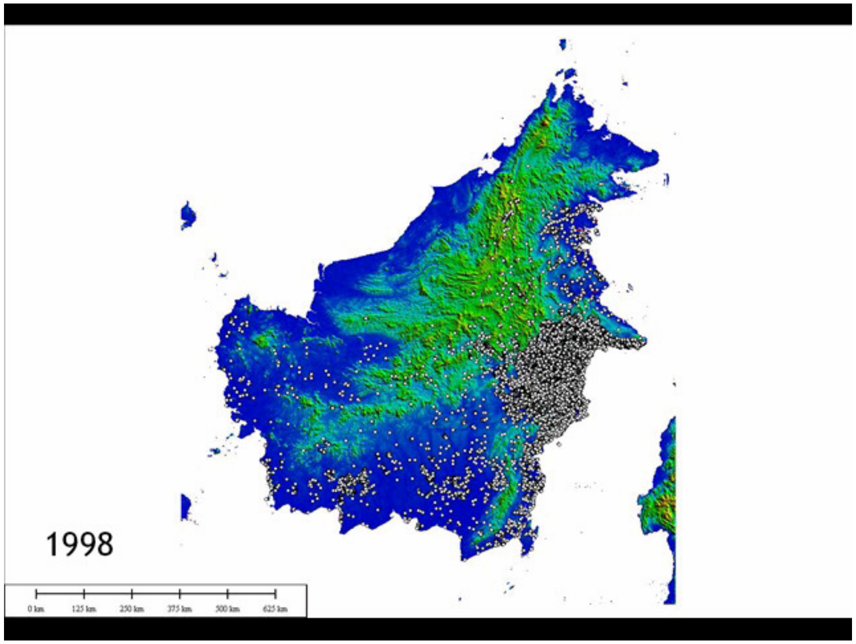
DGVM is a model which is used to simulate interaction between **terrestrial ecosystems (vegetation)** and the **atmosphere (climatology)**

Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model (3)

Spatial Distribution of Fire (Hotspot) in Kalimantan







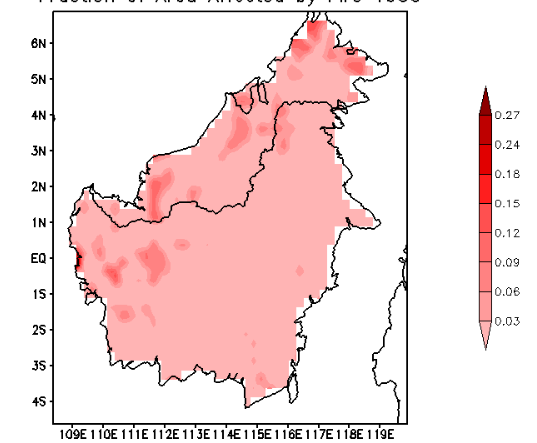
Hotspot in Kalimantan over Years

- Number of hotspot is highly increase after certain level of soil water content
- The relation between number of hotspots and soil water can be used to predict fire probability index

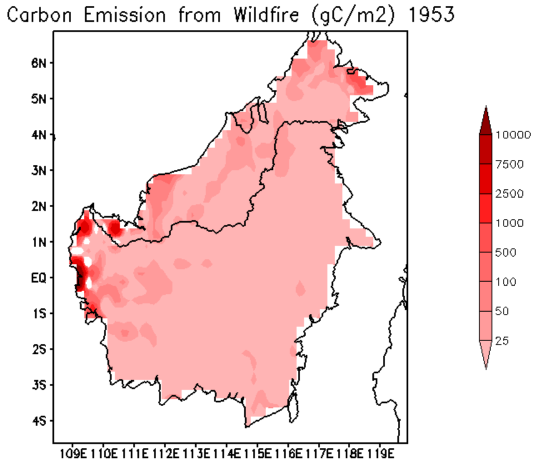
Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model (4)

Simulation Result: Area Affected by Fire

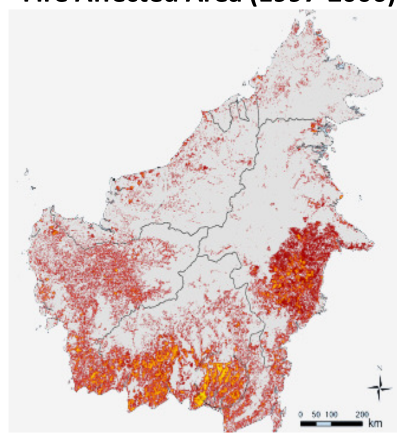
Fraction of Area Affected by Fire 1953



Carbon Emission from Wildfire (gC/m2) 1953

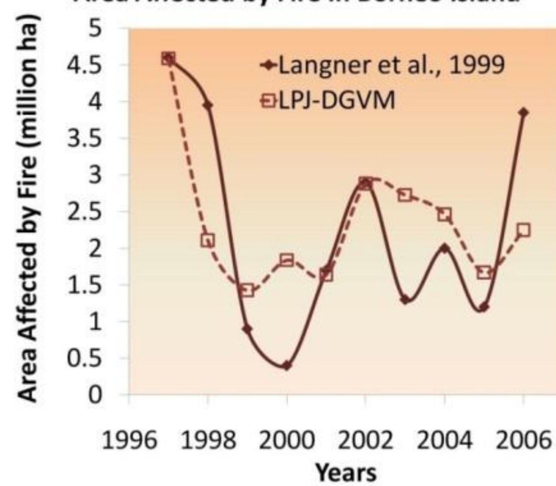


Fire Affected Area (1997-2006)



Langner & Siegert (2009): Compiled from NOAA AVHRR and MODIS hotspot

Area Affected by Fire in Borneo Island

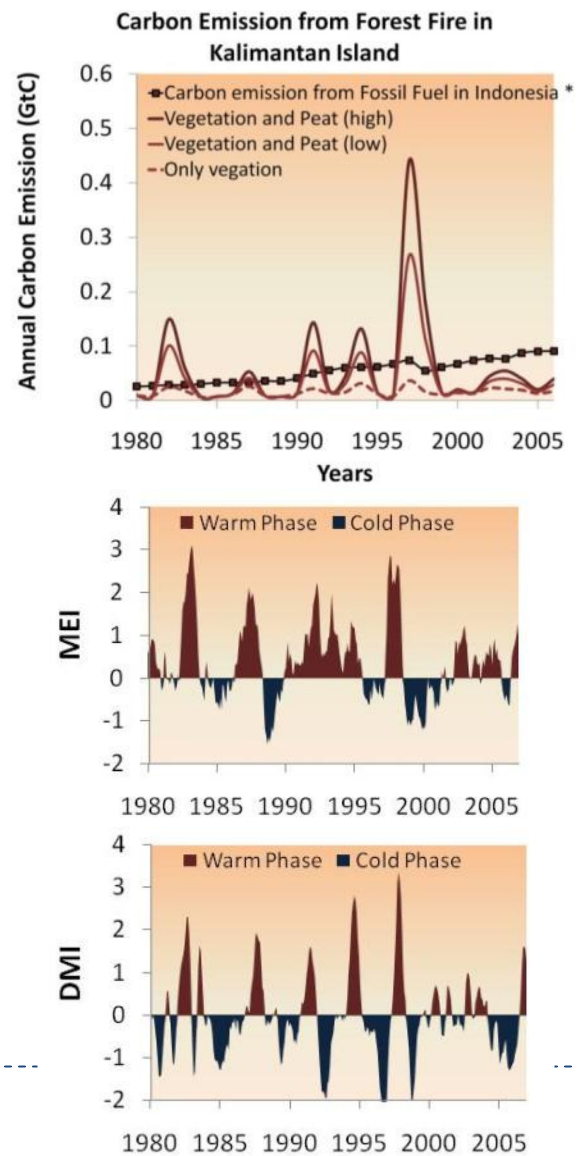


- **Langner & Siegert (2009)** use **satellite data** from NOAA AVHRR/ATRS hotspots (1997-2001) and MODIS hotspot (2002-2006) to analyzed the area affected by fire in Borneo Island.
- Simulation in the **North of Borneo** tends to be overestimate (due to the absence of air humidity in defining fire occurrence). In **East Kalimantan**, high emission is predicted from area to the North of Samarinda, with slightly overestimate in the area near Tarakan. In **West Kalimantan**, simulation result shows similar pattern with the satellite data.

Risk Assessment of Forest Fire Generated by Potential Water Scarcity Model (5)

Simulation Result: Carbon Emission from Forest Fire

- Based on this 1997-1998 forest fire, **three scenarios** of fire emission are used:
  1) **High scenario** by assuming ~50cm of peat is burned,
  2) **Low scenario** by assuming ~25cm of peat is burned, and
  3) by assuming **no peat fire**.
- The **average carbon emission** from 1980 to 2006 is between **0.02 GtC/year** (for no peat scenario) to **0.06 GtC/year** (for high scenario).
- During 1997-1998, the total carbon emission from forest fire is between **0.05GtC** (for no peat scenario) to **0.62GtC** (for high scenario).
- During **extreme drought**, carbon emission from forest fire might be **higher than carbon emission from fossil fuel**.



THANK You

Water Resources Engineering Research Group
Faculty of Civil and Environmental Engineering
Institute of Technology Bandung
Indonesia

Website: http://www.ftsl.itb.ac.id/kk/water_resources_engineering/