Historical and Current Water Resource Management in Indonesia: a case study on Jakarta’s coastal area

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Outline of the Talk

1. Jakarta flooding and flood control infrastructures
2. Upstream land use change and flooding downstream
3. Future development plan for Jakarta’s coastal area
Jakarta: Natural and Man-made Threats

Constraining Factors:

- Jakarta is located on a low-lying flat coastal area [40% lower than the surface of the sea] → backwater effect during rainy season.

- **13** rivers flowing and transferring large amount of rainwater into the city of Jakarta.

- Middle and upper parts of the Ciliwung watershed produce large rainfall of ranged between 2,500 – 3,500 mm/year.

- Unintegrated transboundary [upstream-downstream] zones planning including institutional and financial arrangements for transboundary problem solution.
13 Rivers/Canals Flowing in the Java Sea

FURTHER READING:
- Report B1 (Engineering report), report C1.2 (Water Balance) and report C1.6 (Retention Lake Analysis) provide information on the size of the retention reservoir.
- Report B3 (Spatial planning and Urban Design) provide information on the landfalls, infrastructure and regional socio-economic opportunities.
Environmental Issues Faced by Jakarta

Flooding distribution:
- 1992: 61 location
- 1996: 90 location
- 2002: 159 location
- 2005 dan 2007: increased considerably in volume and distribution

Land Use Change
- 1940: 184 (2,120,5 ha)
- 1994: 129 (576,5 ha)

Decreased in water reservoir:
- 1996

Land Subsidence

River water pollution

Fluctuated river flow:
- Qmax/Qmin change from 20 [1996] → 544 [1998]
# History of Political and Infrastructure Changes in Jakarta

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<tbody>
<tr>
<td>Hindu and local religion</td>
<td>Islam</td>
<td>Islam</td>
<td>Islam</td>
<td>Islam</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Political ruler</th>
<th>Sunda Kingdom</th>
<th>Cirebon backup by Central Java</th>
<th>J.P. Coen collaborate with local land lords [72 sugar &amp; 117 other companies]</th>
<th>Transition to the independent of Indonesia [1945] and current democratic government</th>
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<td>King Surawisesa</td>
<td>Suster Demak</td>
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<tr>
<th>Canal for water transport and drying up wet lands</th>
<th>810 m</th>
<th>1,825 m</th>
<th>3,250 m</th>
<th>See separate slides</th>
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<tr>
<th>Flood control infrastructures</th>
<th>Canal</th>
<th>Canal</th>
<th>Reservoir, west canal, river regulators &amp; Polders</th>
<th>Reservoir, west and east canals, river regulators, pump &amp; polders, recharge wells, RWH, proposed deep tunnel</th>
</tr>
</thead>
</table>
Batavia in **1619** under control of J.P. Coen, president of the VOC [Verenegde Oost Indische Compagnie]

- Gede Mountain
- Pangrango Mountain
- Salak Mountain
- Hollandia Fortress
- Ciliwung River
Peta 8
KOTA BATAVIA,
TAHUN 1672

Source: Ministry of Education and Culture [1983]
Batavia in 1935

Developed Areas

Rice fields

Swamp

Wet lands

Ciliwung River
The back shift of Jakarta's Coastal Line
[Sea level rise more dominant than river sedimentation]
Flooding in Batavia/Jakarta

1918

1932

2002

2005
Flooding Distribution in Jakarta [1965]

Flooding was mainly distributed along the Ciliwung River.
Comparison of Flooding in 2007 and 2013

PERBANDINGAN BANJIR 2007 & 2013

<table>
<thead>
<tr>
<th>No.</th>
<th>KRITERIA</th>
<th>2007</th>
<th>2013</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Luas Genangan</td>
<td>231.8 KM2</td>
<td>41 KM2</td>
</tr>
<tr>
<td>2</td>
<td>Prosentase terhadap luas DKI</td>
<td>45%</td>
<td>8%</td>
</tr>
<tr>
<td>3</td>
<td>Jumlah Pengungsi</td>
<td>320.000 jiwa</td>
<td>18.018 jiwa</td>
</tr>
<tr>
<td>4</td>
<td>Korban Meninggal</td>
<td>80 org</td>
<td>20 org</td>
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</tbody>
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Groundwater mining in Jakarta [1879 – 2007]

Penyedotan (juta meter kubik / tahun)

Jumlah Total Sumur

Penyedotan  Jumlah Sumur

0  500  1,000  1,500  2,000  2,500  3,000  3,500  4,000

0  5  10  15  20  25  30  35  40

Land Subsidence in Jakarta 1974

- 4.04 m
- 3.22 m
- 2.42 m
- 1.61 m
- 0.80 m
- 0.25 m
- 1.4 m
- 2.1 m
- 4.1 m
In 1918, Dr. Van Breen of Departement Waterstaat proposed an integrated flood control in the form of flood canal [west flood canal]
Form of Flood Control:

1. **Flood canals** → West flood canal protecting 7,500 ha flood area and proposed east canal protecting 36,500 ha flooding area

2. **Main drainage system** → natural flowing water [gravity driven water flow]

3. **Pump and polder system** → pumping water out to protect a total of 24,000 flooding area.
Master Plan of Flood Control in Jakarta [1973]
Jakarta Emergency Dredging Initiative
(Jakarta Urgent Flood Mitigation Project)

JAKARTA URGENT FLOOD MITIGATION PROJECT (JUFMP/JEDI) Package 2A IBRD LOAN NO.8121-ID

DATA TEKNIS
- Luas DAS = 459 km²
- Panjang Sungai Utama (L) = 7.9 km
- Panjang Sungai Yang Ditangani = 7.8 km
- Lebar Sungai = 60 - 70 meter
- Debit Existing = 300 – 340 m³/det
- Debit Banjir Rencana (Q50) = 566 m³/detik
- Sumber Dana = IBRD LOAN No.8121-ID

MANFAAT PEKERJAAN:
Meningkatkan Kapasitas Sungai dan Penataan Kawasan
Transfering water from Ciliwung river to East Canal

**SUDETAN KALI CILIWUNGA KE KANAL BANJIR TIMUR**

**DATA TEKNIS:**
- PANJANG SUDETAN = 1,27 Km
- JUMLAH PIPA = 2 Buah
- DIAMETER DALAM PIPA = 3.5 M
- DIAMETER LUAR PIPA = 4.0 M
- TIPE ALAT BOR = EPB dia 4 M 2 Unit

**MANFAAT:**
Mengalirkan sebagian debit Banjir Kali Ciliwung sebesar 60 m3/det

**LOKASI:** DKI JAKARTA
Alt 1. (Studi Nikken 1997)
- Jarak Inlet Sudetan ke Katulampa ± 3,5 km
- Panjang Sudetan ± 1 km
- Ø 2 x 8.1 m
- Q = 2 x 300 m³/dtk

Alt 2. (Studi FHM 2013)
- Jarak Inlet Sudetan ke Katulampa ± 0,2 km
- Panjang Sudetan ± 2.9 km
- Ø 1 x 6.5 m
- Q = 1 x 100 m³/dtk
NORMALISASI KALI CILIWUNG LAMA
Lokasi Pekerjaan : PA. Manggarai – Jemb. Masjid Istiqlal
Panjang : 8.5 KM
Lebar Penampang : 15 m – 20 m
Debit Banjir : 70 m³/det

MANFAAT PEKERJAAN:
Meningkatkan Kapasitas Sungai dan Penataan Kawasan

LOKASI:
DKI JAKARTA
Reconstruction of Water Pump for Pluit Reservoir

DATA TEKNIK POMPA EXISTING
1. Pompa Pluit Timur (P1) (sedang Rekonstruksi)
   - Kapasitas : 3 x 5 m³/dt = 15 m³/dt
   - Operasi : 0 x 5 m³/dt = 0 m³/dt
2. Pompa Pluit Tengah (P2)
   - Kapasitas : 4 x 4 m³/dt = 16 m³/dt
   - Operasi : 3 x 4 m³/dt = 12 m³/dt
3. Pompa Pluit Barat (P3)
   - Kapasitas : 3 x 6 m³/dt = 18 m³/dt
   - Operasi : 1 x 6 m³/dt = 6 m³/dt
Total Kapasitas Maksimum Pompa = 49 m³/dt
Total Kapasitas Operasi Pompa sekarang = 18 m³/dt

Lingkup Pekerjaan Renovasi Pompa Timur (Pompa Baru 3 x 5 m³/det)

1. Rekonstruksi Stasiun Pompa Timur
   - Ruang pompa timur : Struktur beton bertulang L 15,6m x W 11,0m x (D 10m + H 12,7m), Pondasi Pipa Baja
   - Pekerjaan Bangunan : Beton Bertulang 3 Lantai, Luas lantai 350m², Pondasi Pipa Baja.
   - Struktur Inlet : Struktur Beton bertulang, Pondasi Pipa Baja.
   - Struktur Terowongan Pipa pembuangan
   - Struktur Pipa Muara
2. Pemasangan Sarana Pompa di Stasiun Pompa Timur
   - Sarana Pipa Pembuangan (Kapasitas 5,0m³/dt) : 3 Unit
   - Sistem saluran pipa di atas tanah (dia 1.500mm) : 3 set
   - Sarana Generator Darurat (1.500 kVA) : 1 set
   - Saringan dan alat pembantu : 3 unit
   - Alat pengangkut horizontal
3. Konstruksi Tanggul Air Pasang Laut di depan semua Stasiun Pompa
   - Cantilever Steel Sheet Pile dan Tanggul jenis Counterweight sepanjang ± 145m
   - Pekerjaan pengerukan
   - Pekerjaan pengaman dasar laut
Proposed Development of Ciawi and Sukamanah Reservoirs

**Bendungan Ciawi**
- Luas DTA: 88.50 km²
- Luas Genangan: 32.82 ha
- Vol. Tampungan Maks.: 6.45 x 10^6 m³
- Tipe Bendungan: Urugan
- El. Puncak Bendungan: El. 551.00 m
- Tinggi Bendungan diatas fondasi: 55.00 m dan diatas dasar sungai: 51.00 m
- Panjang Bendungan: 341.00 m

**Bendungan Sukamahi**
- Luas DTA: 15.86 km²
- Luas Genangan: 8.2 ha
- Vol. Tampungan Maks.: 1.707 x 10^6 m³
- Tipe Bendungan: Urugan
- El. Puncak Bendungan: El. 601.00 m
- Tinggi Bendungan diatas fondasi: 47.00 m dan diatas dasar sungai: 47.00 m
- Panjang Bendungan: 198.00 m

*(sumber: Studi Kons. BBWS CC, 2014)*
Flooding in Jakarta: Upstream Ciliwung watershed degradation and back water effects
THE IMPACTS OF AGRICULTURAL DEVELOPMENT LEADING TO HOMOGENIZATION OF THE AGRICULTURAL LANDSCAPE IN WEST JAVA → INCREASING RUN-OFF AND SOIL EROSION/RIVER SEDIMENTATION

Degraded soil in West Java > 75% is in private lands → Big challenge to successful soil and water conservation programs
Typical erosive agricultural practices in private lands, West Java
Land use change in the Upper Ciliwung Watershed (1990-1999)
## Land Use Change in Ciliwung Watershed [2002-2009]

Source: Sriharto (2011) in *Kompas*, 3 April 2012

<table>
<thead>
<tr>
<th>Land Use</th>
<th>2002 (%)</th>
<th>2009 (%)</th>
<th>Land Use Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice field</td>
<td>11.7</td>
<td>0.5</td>
<td>-11.2</td>
</tr>
<tr>
<td>Plantation</td>
<td>0.3</td>
<td>24.5</td>
<td>24.2</td>
</tr>
<tr>
<td>Forest</td>
<td>25.8</td>
<td>6.2</td>
<td>-19.6</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.5</td>
<td>8.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Shrubs</td>
<td>19.0</td>
<td>0.2</td>
<td>-18.8</td>
</tr>
<tr>
<td>Settlement</td>
<td>42.3</td>
<td>59.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Water bodies</td>
<td>0.4</td>
<td>0.3</td>
<td>-0.2</td>
</tr>
<tr>
<td>Wet lands</td>
<td>0.1</td>
<td>0.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Runoff Coefficient
Ciliwung Watershed

BATAS DAS/SUBDAS
JALAN
SUNGAI

NILAI KOEFISIEN ALIRAN

<table>
<thead>
<tr>
<th>Penggunaan</th>
<th>Count</th>
<th>KOEF_C</th>
<th>LUAS (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danau/Waduk</td>
<td>115</td>
<td>0.010</td>
<td>5446.0</td>
</tr>
<tr>
<td>Hutan</td>
<td>5</td>
<td>0.100</td>
<td>1243.0</td>
</tr>
<tr>
<td>Hutan Belukar</td>
<td>37</td>
<td>0.200</td>
<td>24591.0</td>
</tr>
<tr>
<td>Hutan Lindung</td>
<td>11</td>
<td>0.100</td>
<td>15274.0</td>
</tr>
<tr>
<td>Kebun Campuran</td>
<td>73</td>
<td>0.500</td>
<td>151961.0</td>
</tr>
<tr>
<td>Pelabuhan Udara</td>
<td>1</td>
<td>0.600</td>
<td>1762.0</td>
</tr>
<tr>
<td>Pemukiman</td>
<td>845</td>
<td>0.800</td>
<td>141219.0</td>
</tr>
<tr>
<td>Perkebunan</td>
<td>34</td>
<td>0.400</td>
<td>16140.0</td>
</tr>
<tr>
<td>Rawa</td>
<td>41</td>
<td>0.010</td>
<td>13941.0</td>
</tr>
<tr>
<td>Rumput</td>
<td>86</td>
<td>0.350</td>
<td>6692.0</td>
</tr>
</tbody>
</table>
The five-year moving average of daily **minimum streamflow** for both stations were decreased with $r = 0.97$ and $0.93$, respectively.

**Daily minimum discharge at the Ciliwung Watershed**

- **Qmin Sugutamu (R-5)**
- **Qmin Katulampa (R-5)**
- **Trend Qmin Sugutamu**
- **Trend Qmin Katulampa**

**Equations**:

- $ys = -0.9505x + 13.022$  
  $R^2 = 0.87$
- $yk = -0.8797x + 8.5178$  
  $R^2 = 0.92$
The five-year moving average of daily maximum streamflow for both Katulampa and Sugutamu hydrological stations were increased overtime with $r = 0.77$ and $0.83$, respectively.

\[ y_s = 16.587x + 57.224 \]
\[ R^2 = 0.69 \]

\[ y_k = 3.0121x + 39.913 \]
\[ R^2 = 0.58 \]
Backwater effect in the coastal area of Jakarta [2010]
In 1990, just 12% or 1,600 ha coastal area of Jakarta under sea level. In just 20 years [2010], 58% or more of 8,000 ha coastal area of Jakarta under the sea level. Without significant efforts, it is predicted that in 2030, 90% or 12,500 ha of coastal Jakarta will be inundated.
Desirable Landscape for Minimizing Downstream Sedimentation
Managed *Pinus Merkusii* forest plantation in Central Java: reduced surface run-off and soil erosion
Managed *Agroforestry* in West Java: reduced surface run-off and soil erosion
Managed Dry-land Farming in Central Java: reduced surface run-off and soil erosion
Strategy for better Landscape Management and for Flood Mitigation

- Establish an improved water resource-related organization focusing more on a multi-disciplinary and transboundary institutional approach for an integrated spatial planning. This organization should consider the important of upstream-downstream cash flow as part of the compensation mechanism.

- It is important to involve large companies in Jakarta such as the Jakarta International Airport, the Jakarta International Seaport, and other Jakarta-based large companies that suffered from flooding to contribute financially to the proposed program.

- To encourage rural people to participate, it is important to implement incentive and dis-incentive system. This large scale movement program should involve economists, sociologists, anthropologists, and other social scientists for getting a widespread public acceptance.
Master Plan 2014-2025

National Capital Integrated Coastal Development [NCICD]
Jakarta Coastal Development

- National Development Planning Agency
- Ministry of Public Works
- Government of the Netherlands
Development Plan for Jakarta’s Coastal Area [Great Sea Wall]

AS HARBOUR, INDUSTRIAL, AND WAREHOUSE FUNCTIONS THROUGH LAND RECLAMATION DAN REVITALIZATION

WESTERN AREA (HOUSING)
- Pantai Kapuk
- PLUIT
- Soekarno-Hatta International Airport

CENTRAL AREA (CBD)
- Jakarta Old City
- Ancol
- Outer Ring Road
- Inner Ring Road

EASTERN AREA (INDUSTRY)
- Outer Outer Ring Road
- Outer Ring Road
- Harbour Toll Road
- Port of Tanjung Priok
- Karang Tanjung Toll Road
- Marunda
- Rencana Rel KA

AS HARBOUR, INDUSTRIAL, AND WAREHOUSE FUNCTIONS THROUGH LAND RECLAMATION DAN REVITALIZATION
POISED IN THE MIDDLE OF THE GREAT WING-SHAPED SEA WALL WILL BE A NEW CENTRAL CITY AREA, POSITIONED AS A NATURAL EXTENSION OF THE CENTRAL SPINE AREA OF JAKARTA, IT WILL PROVIDE A SPECTACULAR AND WARM WELCOME TO ALL WHO COME TO THE NATION’S CAPITAL.

3500-4000 ha of land reclamation

Closed giant reservoir, giant wall, & giant pump.
New Airport

Sea

Reclamation for commercial uses
MULTI PURPOSE DEEP TUNNEL AS EMERGING SOLUTION INTEGRATED WATER MANAGEMENT
Thank You All