Striving for a Balanced Development on the Okavango River Basin

Dominic Mazvimavi

Institute for Water Studies
Okavango River in Southern Africa
The Transboundary Okavango River
<table>
<thead>
<tr>
<th></th>
<th>Angola</th>
<th>Namibia</th>
<th>Botswana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (millions)</td>
<td>16.8</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Population growth</td>
<td>2.7%</td>
<td>1.0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Per capita income</td>
<td>US$4,400</td>
<td>US$5,120</td>
<td>US$12,420</td>
</tr>
<tr>
<td>GDP growth rate (avg 5 yrs)</td>
<td>15%</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Population with improved</td>
<td>50%</td>
<td>92%</td>
<td>95%</td>
</tr>
<tr>
<td>water supply</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural popn with improved</td>
<td>38%</td>
<td>88%</td>
<td>90%</td>
</tr>
<tr>
<td>water supply</td>
<td></td>
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</tbody>
</table>
### Okavango Basin

<table>
<thead>
<tr>
<th></th>
<th>Angola</th>
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<th>Botswana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin popn</td>
<td>505,000</td>
<td>219,000</td>
<td>157,690</td>
</tr>
<tr>
<td>Proportion of national popn</td>
<td>3.0%</td>
<td>10.5%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Urbanization in the basin</td>
<td>48%</td>
<td>20%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Mean annual rainfall

- 1200-1300
- 1100-1200
- 1000-1100
- 900-1000
- 800-900
- 700-800
- 600-700
- 500-600
- 400-500
- 300-400
- 200-300
- Maun
<table>
<thead>
<tr>
<th></th>
<th>Angola</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Uses</td>
<td></td>
<td></td>
<td>99.2%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>0.2%</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Water Supply</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

Present Use of Basin Water (Approx 10,000 Mm³/yr)
Contribution of Okavango River & Wetland Natural Resources to Livelihoods and National Economies

- **Livelihoods**
- **Direct GNI**
- **Total GNI**

Million US Dollars

- **Angola**
- **Namibia**
- **Botswana**
- **Whole Basin**

Uses considered at household level – fishing, grass, gardens, grazing, & tourism
Angola – Contribution to Household Income (US$4.4million)

- Fish: 50%
- Reeds: 13%
- Grass: 31%
- Gardens: 1%
- Grazing: 2%
- Tourism: 3%
Namibia – Contribution to Household Income (US$8.2 million)

- Tourism: 45%
- Fish: 18%
- Grass: 21%
- Grazing: 5%
- Gardens: 4%
- Reeds: 7%
- Tourism: 45%
- Fish: 18%
- Grass: 21%
- Grazing: 5%
- Gardens: 4%
- Reeds: 7%
Botswana – Contribution to Household Income (US$ 22.7 million)

- Tourism: 94%
- Fish: 1%
- Reeds: 1%
- Grass: 2%
- Gardens: 1%
- Grazing: 1%
Permanent Okavango River Basin Water Commission (OKACOM)

• Established in 1994 by Angola, Namibia & Botswana.

• To determine the long-term safe yield of water resources of the basin.

• Determine the reasonable demand for water.

• Develop criteria for equitable allocation and sustainable utilization.

• Prevent water pollution and control aquatic weeds.
Objectives of the Environmental Flow Assessment (2008-2009)

• To establish effects of possible future developments on flow regimes of the Okavango River.

• To determine effects of changes of flow regimes on physio-chemical, ecological and socioeconomic attributes of the Okavango River.

• Contribute to the development of criteria for water allocation
Methods

• A scenario based approach
• Scenarios included possible future developments.
• Delineation of the basin into homogenous zones based on
  ➢ Hydrological
  ➢ Geomorphological
  ➢ Water quality
  ➢ Biological
  ➢ Socioeconomic criteria
Methods ....

• Selection of study sites in each zone.
• Identification of flow-related biophysical indicators
• Determination of flow responses to development.
• Development of response curves
• Integration of responses within at DSS – multicriteria analysis
Team Work

• Each country with a team participating.
• Multidisciplinary
• Hydrology, hydraulics, geomorphology, water quality, aquatic invertebrates, fish, birds, terrestrial fauna, aquatic mammals, anthropology, resources economics, health, tourism
Site 1: Cuebe River at Capico, Angola
Site 2: Cubango River at Mucundi, Angola
Site 3 Cuito River at Cuanavale, Angola
Site 4 Okavango River at Kapako, Namibia
Site 5 Okavango River at Popa Rapids
Inflows into the Delta (Site 5/6)
Mean Monthly Flow

Cubango

Cuito
Site 6 Okavango River – Panhandle, Botswana
Site 8 Delta

Panhandle

Permanent Swamp

Seasonal Swamp

Occasionally Flooded
Site 7 Delta

Present day conditions

Proportion of Xakanaxa area occupied by veg classes

year


Savanna
Grassland
Sedgeland
Backswamps
Site 8 Boteti River at Chanoga, Botswana
Outflows from the Delta

Maun, Samedupi & Rakops flows (m3/s)
# Scenarios – Present Day

<table>
<thead>
<tr>
<th>Country</th>
<th>Developments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>• 47 Mm³/yr irrigation in Angola</td>
</tr>
<tr>
<td></td>
<td>• Angola Urban water 11 Mm³/yr</td>
</tr>
<tr>
<td>Namibia</td>
<td>• Namibia, Rundu, urban 2.8 Mm³/yr</td>
</tr>
<tr>
<td></td>
<td>• Namibia, 2,700 ha or 33 Mm³/yr</td>
</tr>
<tr>
<td>Botswana</td>
<td>• Botswana rural 4 Mm³/yr</td>
</tr>
<tr>
<td></td>
<td>• Botswana urban 21 Mm³/yr</td>
</tr>
</tbody>
</table>
## Low Development

<table>
<thead>
<tr>
<th></th>
<th>Angola</th>
<th>Namibia</th>
<th>Botswana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18,000 ha irrigation</td>
<td>3,100 ha irrigation</td>
<td>• Botswana rural 4 Mm³/yr</td>
</tr>
<tr>
<td></td>
<td>3 run-of-river HEP</td>
<td>Rundu 3 Mm³/yr</td>
<td>• Botswana urban 21 Mm³/yr</td>
</tr>
<tr>
<td></td>
<td>1250 Mm³ reservoir for HEP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecosystem Uses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Namibia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecosystem Uses</td>
<td>Angola</td>
<td>Namibia</td>
<td>Botswana</td>
</tr>
<tr>
<td></td>
<td>Ecosystem Uses</td>
<td>Irrigation</td>
<td>Water Supply</td>
</tr>
<tr>
<td></td>
<td>95.1</td>
<td>4.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>Region</td>
<td>Details</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angola</td>
<td>198,000 ha&lt;br&gt;4 HEP (run-of-the river)&lt;br&gt;1250 Mm$^3$ reservoir for HEP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Namibia</td>
<td>17 Mm$^3$/yr Diversion into the Eastern National Carrier&lt;br&gt;8,400 ha irrigation&lt;br&gt;3.4 Mm$^3$/yr for Rundu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## High Development

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
</tr>
</thead>
</table>
| Angola      | 338,000 ha irrigation  
9 run-of-the river HEP  
1250 Mm$^3$ reservoir for HEP |
| Namibia     | 100 Mm$^3$/yr Diversion into the Eastern National Carrier  
15,000 ha irrigation  
4.3 Mm$^3$/yr Rundu  
Run-of-the River HEP at Popa |
| Botswana    | 37 Mm$^3$ dam at Samedupi |
Hydrological Modelling
Locations of Abstractions & Storages – Upper Part
Location of Abstractions & Storages – Middle Part
## Dry Season Onset

<table>
<thead>
<tr>
<th>Site</th>
<th>Present</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aug</td>
<td>May</td>
<td>May</td>
<td>May</td>
</tr>
<tr>
<td>2</td>
<td>July</td>
<td>July</td>
<td>July</td>
<td>July</td>
</tr>
<tr>
<td>3</td>
<td>July</td>
<td>July</td>
<td>July</td>
<td>July</td>
</tr>
<tr>
<td>5/6</td>
<td>Aug</td>
<td>July</td>
<td>July</td>
<td>June</td>
</tr>
</tbody>
</table>
## Change of Dry Season Flows

<table>
<thead>
<tr>
<th>Site</th>
<th>Present Flow (m³/s)</th>
<th>Low % change</th>
<th>Medium % change</th>
<th>High % change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>-97</td>
<td>-98</td>
<td>-98</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>-50</td>
<td>-63</td>
<td>-25</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>-43</td>
<td>-57</td>
<td>-46</td>
</tr>
<tr>
<td>5/6</td>
<td>114</td>
<td>-11</td>
<td>-18</td>
<td>-82</td>
</tr>
</tbody>
</table>
# Change of Median Peak Flow

<table>
<thead>
<tr>
<th>Site</th>
<th>Present Flow (m³/s)</th>
<th>Low % change</th>
<th>Medium % change</th>
<th>High % change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>-8</td>
<td>-8</td>
<td>-8</td>
</tr>
<tr>
<td>2</td>
<td>429</td>
<td>0</td>
<td>0</td>
<td>-7</td>
</tr>
<tr>
<td>4</td>
<td>452</td>
<td>-1</td>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>5/6</td>
<td>620</td>
<td>0</td>
<td>-1</td>
<td>-8</td>
</tr>
</tbody>
</table>
## Impacts on the Delta

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avg Inflow (Mm³/yr)</strong></td>
<td>9600</td>
<td>-3.9</td>
<td>-9.2</td>
<td>-30.2</td>
</tr>
<tr>
<td><strong>Permanent Swamps (%)</strong></td>
<td>49.1</td>
<td>-3.1</td>
<td>-6.1</td>
<td>-37.7</td>
</tr>
<tr>
<td><strong>Seasonal Swamps (%)</strong></td>
<td>43.6</td>
<td>2.3</td>
<td>4.2</td>
<td>14.1</td>
</tr>
<tr>
<td><strong>Drylands (%)</strong></td>
<td>6.5</td>
<td>0.7</td>
<td>1.8</td>
<td>23.3</td>
</tr>
</tbody>
</table>
Boteti River D/S of Delta
Ecological Integrity

A = unmodified, B = largely natural, C = Moderately modified, D = Largely modified, E = Extensive loss of ecosystem functions, F = Irreversible destruction
## Negotiating Development Pathway

### Medium Dev

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<th>Botswana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Uses</td>
<td></td>
<td></td>
<td>88.4%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>9.9%</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>Water Supply</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

### High Dev

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</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Uses</td>
<td></td>
<td></td>
<td>64.5%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>32.0%</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>Water Supply</td>
<td>0.2%</td>
<td>1.0%</td>
<td>0.4%</td>
</tr>
</tbody>
</table>
Conclusion

• Greatest impact from irrigation:
   Angola 3300 Mm³/yr
   Namibia 223 Mm³/yr

• Namibia inter-basin transfer 100 Mm³/yr

• Possible costs and benefits of development options established at the local, national & transboundary level.
• Results of EFA provides a basis for negotiating development pathways.

• Need to establish the maximum acceptable modification of the river system – a political decision.

• Acceptance of adopting a river basin approach for the development of the Okavango Basin

• Challenge is to link local and national plans to the transboundary basin management plan.

• Planning of transboundary basins requires teams truly representative of the riparian states.
• Need to improve the understanding of the linkages between flow regimes + ecological response + socioeconomic aspects.
• SADC countries with abundant water + countries which will face scarcity.

• EFA can contribute to exploring costs & benefits of sharing developing transboundary level.
Acknowledgements

OKACOM

EPSMO
What are we doing at the University of the Western Cape

• Enhance the understanding and management of Surface Water – Groundwater – Ecosystems Linkages, and how Society is affected and affects these linkages
Research Thrusts

i. Groundwater
ii. Surface Water
iii. Water Quality
iv. Plant - water relationships
v. Integrated water resources management
vi. Water and human welfare
Groundwater

- Fractured aquifer systems
- Table Mountain Group aquifers – groundwater storage, flow and recharge.
- Groundwater recharge and pollution in the Cape Flats
- Modelling contaminants in the unsaturated zone.
Subsurface flow of water in fly ash
Surface Water

- Long-term variations of river flows and rainfall.
- Effects of land cover/use change on freshwater.
- Effects of water resources development on the availability of freshwater.
- Sediment erosion, transport and deposition in rivers.
Water Quality

- Estrogenic contaminants in sewage effluents
- Biomarkers for endocrine disruptors
- Non-point sources of pollution from agriculture
- Nitrate leaching from alien vegetation
- Assessment of non-point sources of pollution using GIS in the Kuils-Eerste River catchment.
COOPERATIVE GOVERNANCE

BUREAUCRATIC GOVERNANCE

- NATIONAL GOVERNMENT DEPARTMENTS.
- PROVINCIAL GOVERNMENT DEPARTMENTS.
- LOCAL GOVERNMENT AUTHORITIES. (SALGA)
- OTHERS.

DELEGATED GOVERNANCE

- WB
- CMA
- WUA
- PSP
Water and society

- Relationships between water and human welfare (water for food, human health)

- Knowledge and the way different stakeholders engage with each other and with the State, and how this affects water governance and sustainable solutions to water management
Postgraduate Training

- 17 BSc Honours
- 20 Postgraduate Diploma in IWRM
- 30 MSc students
- 8 PhD students