IMPACT OF CLIMATE CHANGE ON WATER AVAILABILITY AND EXTREME FLOWS IN ADDIS ABABA
Contents

- Background of climate change
- Climate Change Studies in and Around Addis Ababa
- Impact of climate change on Water Availability
- Impact of Climate change on Extreme Flow Conditions
- Implications on Socio-economic setting of Addis Ababa
1: Global Climate Change

**Weather** is the short term (i.e. minutes to days) status of the atmosphere in terms of pressure, humidity, cloud cover, temperature, etc.

**Climate** is defined as the long-term average weather (IPCC, 1997)

The statistical description of the mean and variability of temperature, precipitation, humidity, wind, and other climatic variables over several decades (typically 3 or more as defined by WMO) defines the climate of a region.
The Climate System
Atmospheric Composition

- Minor gases are as important as the major ones
- In addition we have 1-4% of water vapor
The Greenhouse Effect

1. Solar radiation passes through the clear atmosphere.
   *Incoming solar radiation: 343 Watt per m²*

2. Net incoming solar radiation: 240 Watt per m²

3. Some solar radiation is reflected by the atmosphere and Earth’s surface.
   *Outgoing solar radiation: 103 Watt per m²*

4. Solar energy is absorbed by the Earth’s surface and warms it...
   *168 Watt per m²*

5. Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the earth’s surface and the troposphere.

6. Some of the infrared radiation passes through the atmosphere and is lost in space.
   *Net outgoing infrared radiation: 240 Watt per m²*

Surface gains more heat and infrared radiation is emitted again... and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere.
Global Warming

<table>
<thead>
<tr>
<th>GHG</th>
<th>Pre-Industrial (1750-1800)</th>
<th>Current (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>280 ppm</td>
<td>379 ppm</td>
</tr>
<tr>
<td>Methane</td>
<td>715 ppb</td>
<td>1774 ppb</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>270 ppb</td>
<td>319 ppb</td>
</tr>
</tbody>
</table>

CFCs were not present in the atmosphere before the 1930s

Source: IPCC 2007, IPCC 1997
Global Warming

Source: IPCC 2007
What Happened till Now?

- 11 of the last 12 years (1995-2006) rank among the 12 warmest years (since 1850).
- The 100-year linear trend (1906–2005) is 0.74 [0.56 to 0.92]°C. The linear warming trend over the last 50 years is 0.13 [0.10 to 0.16]°C per decade.
- The average atmospheric water vapour content has increased.
Global and Continental Temperature Change
What is Expected?

**AOGCM Projections of Surface Temperatures**

- **B1: 2020-2029**
- **B1: 2090-2099**
- **A1B: 2020-2029**
- **A1B: 2090-2099**
- **A2: 2020-2029**
- **A2: 2090-2099**

**Global Average Surface Temperature Change (°C)**

![Graph showing projected temperature changes](image-url)
What is Expected?

Projected Patterns of Precipitation Changes

- multi-model
- A1B
- DJF multi-model
- A1B
- JJA

©IPCC 2007: WG1-AR4
What is the observational data show over Ethiopia?

Annual variability of rainfall over Northern half (left side) and Central (right) Ethiopia expressed in normalized deviation (NMSA, 2001) - from 42 met stations
Projected climate Change over Ethiopia

- Composite (average of 19 GCMs) percentage change (%) in rainfall relative to 1961-1990 normal for A1B emission scenario
  - A small increase in annual precipitation
the mean annual temperature will increase in the range of 0.9 - 1.1 °C by 2030,
in the range of 1.7 - 2.1 °C by 2050
in the range of 2.7 - 3.4 °C by 2080
What is the observational data show over Ethiopia?

(a) Annual mean maximum and (b) minimum temperatures variability and trend over Ethiopia (NMSA, 2001)
conclusion

- Both GCM and Observational data indicates Climate Change is likely real and happening at both global, Regional and local Scale?
WHAT ABOUT IMPACT OF CLIMATE CHANGE IN AND AROUND ADDIS ABABA?
1. Background: Important Rivers in AA Drainage Network

<table>
<thead>
<tr>
<th>Basin</th>
<th>Area (Km²)</th>
<th>River Length (m)</th>
<th>River Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Akaki</td>
<td>172.2</td>
<td>35.6</td>
<td>1/50-1/100</td>
</tr>
<tr>
<td>Little Akaki</td>
<td>30.8</td>
<td>20.5</td>
<td>1/25-1/100</td>
</tr>
<tr>
<td>Kebena</td>
<td>59.8</td>
<td>23.9</td>
<td>1/20-1/100</td>
</tr>
<tr>
<td>Upper Kebena</td>
<td>54.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Kebena</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bantyiketu</td>
<td>29.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bantyiketu</td>
<td>5.4</td>
<td>11.2</td>
<td>1/100</td>
</tr>
<tr>
<td>Kechene</td>
<td>13.6</td>
<td>9.3</td>
<td>1/20-1/50</td>
</tr>
<tr>
<td>Kurtume</td>
<td>10.3</td>
<td></td>
<td>1/20-1/50</td>
</tr>
<tr>
<td>Hanku</td>
<td>11.1</td>
<td>8.6</td>
<td>1/50-1/70</td>
</tr>
</tbody>
</table>
1. Background: Flood damages - Past and future - Past


<table>
<thead>
<tr>
<th>Damage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1978</td>
</tr>
<tr>
<td>People killed</td>
<td>12</td>
</tr>
<tr>
<td>Houses damaged</td>
<td>1255</td>
</tr>
<tr>
<td>Affected population</td>
<td>6000</td>
</tr>
<tr>
<td>Made homeless</td>
<td>‘many’</td>
</tr>
<tr>
<td>Cost of damage</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Flood Affected areas
1. Background: Flood damages - Past and future - Forecasted (2020)

- The projection made by the study (JICA Flood Study) showed that
  - 4,324,928 people,
  - 757,868 houses,
  - 33,590 trailers,
  - 17,024 service organizations, and
  - 4,455 whole sellers are estimated to be under the risk of flooding in 2020

- This has to be verified through modeling efforts
Climate Change Prediction AA - methodology

- GCM Climate Output
- RCM Downscaled Climate Output
- Local Climate (Statistical Downscaled)

- Historical Climate Data
- Historical Flow data

- DEM
  - HEC-GeoHMS Model
  - Watershed Parameters

- HEC-HMS Model
  - (Calibration & Validation)
  - Model parameters
- HEC-HMS Model
  - (Impact Assessment)

- VENSIM Model
  - (Distributed Impact Assessment on large cities)

Expected outputs – impacts on:
- Water availability
- US/DS water interaction
- Storm water/flood
- Drought
- Waste Water
Climate Change Prediction AA – Precipitation

- **1991-2000**
- **2031-2040**
- **2091-2100**

![Graph showing precipitation predictions for different periods, with months on the x-axis and precipitation in mm on the y-axis. The graph illustrates changes expected in precipitation patterns over time, highlighting potential impacts due to climate change.](image-url)
Precipitation

Period

Year range: 1991-2000, 2031-2040, 2091-2100

Seasons: FMAM, JJAS, ONDJ

% Change from the baseline:

2030s change

2090s change

Precipitation, mm
Impact of the projected CC on Water Availability - Akaki Flow

- FMAM
- JJAS
- ONDJ
- Annual

Season

% Change from the baseline

- 2030s change
- 2090s change

% change of flow volume

2030s

2090s

BELG(FMAM)

KIREMT (JJAS)

BEGA(ONDJ)

Annual volume
Coefficient of variation

[Graph showing the coefficient of variation for different years (1990, 2030, 2090) across months from January to December.]
Extreme flow distribution

The graph illustrates the annual maximum steam flow in cubic meters per second (m³/s) as a function of the return period in years. Three different periods are depicted: 1990s (base), 2030s, and 2090s. The flow increases with the return period, indicating a higher flow rate for longer return periods in all three time frames.
Implications

1. For water supply Availability

   - In terms of overall availability water from Akaki River, the supply is likely to be more
   - In terms seasonal water availability, it is likely to be more in Kiremt and Autumn Season
     - this doesn’t mean the availability will be adequate to the city as other demand driving forces are extra-ordinarily groining
Implications

1. *For Extreme hydrological Events*
   - The recurrence of the extreme floods may be more in 2030s for relatively small floods while the high floods is likely to be more in 2090s
   - More likely urban flooding – street flooding due to increased rainfall
   - Need to modify urban infrastructure design criteria
Implications

**Socio-economic**

- Enhanced Rainfall means the impact will be more higher at the downstream community as Autumn rainfall is tending to increase.
- The farmers worry at downstream will increase with rainfall increase in Autumn.