Water–Energy–Food Security Nexus in Ethiopia: promoting synergies and mitigating tradeoffs

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General WEF nexus context in Ethiopia

- 107 million population (second populous country in Africa)
- total estimated area of 110 million hectares (FAO, 2016).

- majority of population depends on agriculture for their livelihoods
  o strong livestock ownership –with 54million (5th in the world and 1st in Africa) (FAOstat.org (2013))
  o Smallholder agriculture –rain-fed and highly vulnerable to changing rainfall and rising frequency of droughts
  o characterized by low levels of input use and low share of irrigated areas in the total cropped land (only 5%) (World Bank, 2006).

- abundant water resources but unevenly distributed, an estimated 2.6 billion m3 of ground water potential less than 10% of the estimated potential of irrigable land under irrigation
General WEF Nexus context in Ethiopia

• 70 million (77%) inhabitants lacked electricity, and about 87 million (95%) still rely on solid biomass energy (IEA, 2014).

• indoor air pollution causing 72,000 death per year in Ethiopia (WHO, 2009)

• highest rates of land degradation in Africa: 4.3 billion USD of losses in ecosystem services annually (Gebreselassie et al 2016), especially through deforestation, soil erosion – higher siltation

• over reliance on hydro-electricity makes the energy sector vulnerable to climate change (Guta and Börner, 2017)
## Major WEF Nexus Drivers

<table>
<thead>
<tr>
<th>Demand side drivers</th>
<th>Supply side drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rapid economic growth-average annual rate of 10.8% between 2003 and 2013 (World Bank, 2015)</td>
<td><strong>Climate change</strong> — challenges on food production, water availability, and hydro-energy production</td>
</tr>
<tr>
<td>o Rapidly increasing nonagricultural demands for water.</td>
<td>• high variability in seasonal and annual rainfall in the country</td>
</tr>
<tr>
<td>o changing preferences for food</td>
<td>• erratic and uncertain — climate change</td>
</tr>
<tr>
<td>o High demand for electricity</td>
<td>• 95% of the crop production is in rain-fed areas, vulnerable to drought</td>
</tr>
<tr>
<td>2. Rapid population growth at 2.6% annually — estimated 107 million in 2017.</td>
<td>• 83% of electricity generation from hydropower, vulnerable to drought</td>
</tr>
</tbody>
</table>
National Policies – strong emphasis on Nexus elements

National Growth and Transformation Plan (GTP II) (2016-2020)

- Irrigation development as an important tool to stimulate sustainable economic growth & rural development - is considered as a cornerstone of food security and poverty reduction

- double the proportion of the population with access to electricity

- develop large-scale hydropower projects - construct a total of 14,561 MW generation projects

Climate Resilient Green Economy (CRGE)

- approach to sustainable economic development and creates a green economy
- aims increase the resilience of the most vulnerable sectors of the economy (including agriculture, water and energy) to climate change (i.e., adaptation)

Four pillars of CRGE

i) improving crop and livestock production practices,
ii) protecting forests and reforestation,
iii) expanding electricity generation from renewable sources
iv) leapfrogging to modern and energy-efficient technologies
## Food insecurity

- Food insecurity is a prominent humanitarian and development concern in Ethiopia.

<table>
<thead>
<tr>
<th>Year</th>
<th>Transitory food insecure *</th>
<th>Chronically food insecure **</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>2.7</td>
<td>7.2</td>
<td>9.9</td>
</tr>
<tr>
<td>2014</td>
<td>2.7</td>
<td>7.2</td>
<td>9.9</td>
</tr>
<tr>
<td>2015</td>
<td>2.9</td>
<td>7.2</td>
<td>10.1</td>
</tr>
<tr>
<td>2016</td>
<td>10.2</td>
<td>7.2</td>
<td>17.4</td>
</tr>
<tr>
<td>2017</td>
<td>5.6</td>
<td>7.8</td>
<td>13.4</td>
</tr>
<tr>
<td>Average</td>
<td>4.82</td>
<td>7.32</td>
<td>12.14</td>
</tr>
</tbody>
</table>

# Ethiopia’s water resource potential

Table 2 Drainage system and their river basins with respective characteristics in Ethiopia

<table>
<thead>
<tr>
<th>Drainage system</th>
<th>River basin</th>
<th>Irrigation potential (ha)</th>
<th>Area of river basin (km²)</th>
<th>Annual flaw (billion m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile Basin</td>
<td>Abay basin</td>
<td>523,000</td>
<td>199,812</td>
<td>52.62</td>
</tr>
<tr>
<td></td>
<td>Baro-akobo</td>
<td>600,000</td>
<td>76,000</td>
<td>23.24</td>
</tr>
<tr>
<td></td>
<td>Setit-tekezea/atbara</td>
<td>189,000</td>
<td>86,510</td>
<td>8.20</td>
</tr>
<tr>
<td></td>
<td>Mereb</td>
<td>500</td>
<td>5,893</td>
<td>0.65</td>
</tr>
<tr>
<td>Rift valley</td>
<td>Awash</td>
<td>205,400</td>
<td>110,000</td>
<td>4.90</td>
</tr>
<tr>
<td></td>
<td>Afar-denekeali</td>
<td>3,000</td>
<td>64,380</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Omo-giba</td>
<td>383,000</td>
<td>79,000</td>
<td>16.60</td>
</tr>
<tr>
<td></td>
<td>Central lake</td>
<td>139,000</td>
<td>52,000</td>
<td>5.64</td>
</tr>
<tr>
<td>Shebelle juda</td>
<td>Wabe-shebelela</td>
<td>204,000</td>
<td>200,214</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>Genale dawa</td>
<td>423,300</td>
<td>168,100</td>
<td>6.10</td>
</tr>
<tr>
<td>North-East coast</td>
<td>Ogaden</td>
<td>0</td>
<td>77,100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gulf of aden/eyesha</td>
<td>0</td>
<td>2,223</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: FAO (2016)
Water Access, Health and Gender Equity

HEALTH

• In remote areas raw water consumption, leading to severe water-borne diseases, especially among young children (Hunter et al., 2009).

• About 38% of deaths of children under the age of five and 25% of disability adjusted life-years are caused by diarrheal and respiratory diseases in the country (WHO, 2010).

• Source of water was found to be among key factors that could influence stunting and malnutrition among children (Alemayehu et al., 2015).

GENDER & EDUCATION

• High water demand coincides with shortage of water and labor (Tucker et al., 2014).

• Water quality and shortage –women and children are affected more.

• Children’s participation in water fetching negatively impacts their school (Beyene et al., 2015).
Sustainable Agricultural Intensification and irrigation

• Sustainable intensification require the introduction of high yielding crop varieties, improving livestock pedigrees, and development of agro-forestry (Awulachew et al., 2005).

• Plan to increase the area under agricultural cultivation by 13%, -conversion of rangelands and forests to agriculture (Karlberg et al. 2015).

• Increasing irrigated lands by about 400% and crop productivity by about 30% -necessitates doubling of fertilizer use (MoFED, 2010)

• Out of 3.8 million hectares of Ethiopia’s potentially irrigable land, only about 0.29 mln hectares (<8%) are irrigated (Frenken, 2005)

• Only 5% of surface waters are utilized for irrigation and the underground water is virtually untapped (Gebreyohannes et al., 2013)

• water-efficient agricultural technologies and practices remains low.

• Significant risk of land degradation in the upstream areas and land use change –decline in surface runoff by 1.5% (Abebe 2015
**Ethiopia’s energy balance**

Table 3 Ethiopia's Energy Supply in 2015

*(In '000 tons of oil equivalent (ktoe) on a net calorific value basis)*

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>253</td>
<td>0.5%</td>
</tr>
<tr>
<td>Oil products</td>
<td>3,041</td>
<td>6.1%</td>
</tr>
<tr>
<td>Hydro-electric</td>
<td>818</td>
<td>1.6%</td>
</tr>
<tr>
<td>Geothermal/solar</td>
<td>65</td>
<td>0.1%</td>
</tr>
<tr>
<td>Bio-fuel</td>
<td>45,813</td>
<td>91.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>49,990</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** International energy Agency (IEA), 2015
Need for energy Transition to modern renewable energy sources

• Transformation of agricultural sector relies heavily on energy transition.

• Hydroelectric potential of the country is about 45GW (160 GWh a year),
  o the installed capacity reached 4,206 MW
  o hydropower provides the bulk of Ethiopia’s total electricity (90%)
  o electricity export or foreign exchange earning.
  o frequent and intense droughts – water shortage
  o siltation due to land degradation and loss of reservoir volume
    (Michael, 2004).
  o hydrological variability may cost Ethiopia about a one-third of its
    growth potential (World Bank, 2006).

• Biogas - potential to produce about 10.6–14.2 million m3 of biogas and
  about 78,000m3 of slurry at the same time (Mengistu et al., 2015).

• Technological solutions, such as the distribution of energy-efficient cook
  stoves and the promotion of alternative ‘modern’ energy sources, such
  as biogas and solar
Empirical evidences

• Analysis of the full system of food and energy production inputs and activities, simultaneity of household choices applying the agricultural household model (AHM):

• Food production and energy production were found to have an important trade-off effect and synergies:

  o Competition for female family labor between fuelwood collection and food production
  o Synergy between food and energy production through tree cultivation by rural households
  o Crop production positively influenced by sustainable land management, better market access, livestock ownership
  o Agro-forestry practices – reduce labour allocation to fuelwood collection and saving labour for food production and non-farm employment
Empirical evidences

• The synergies boosting both household agricultural production and improved access to energy are catalyzed by:
  o Improved access to markets (input, output, credit, insurance)
  o Adoption of agro-forestry practices
  o Livestock ownership
  o Higher input use
  o Adoption of sustainable land management practices
  o Investing in agricultural research and extension

• Subsidies can accelerate energy transition to more efficient and cleaner energy sources in the rural areas of Ethiopia, though to a larger extent among richer households

• Improving access to non-farm jobs seems to have a substantial poverty reduction impact but associated with lower own food production
Key interventions

- **Agricultural intensification** - more irrigation, energy and fertilizer use

**WATER**
- Increasing **water use efficiency and productivity**
- **Integrated watershed management (IWM)** – improve land and water conservation, and increasing crop yields
- Development of **irrigation scheme** – powerful tool to diversify livelihoods and reduce vulnerability to the adverse impacts of climate change

**ENERGY**
- Diversifying the energy mix to alternative renewable sources and use of **energy-efficient technologies** (e.g. waste to energy initiative or land fill gas, the national biogas program, alternative sources such as solar, wind, geothermal)

**LAND**
- Sustainable land management practices such (reduces runoffs, increase crop yield)
Thank you for your attention!