THE NEXUS AMONG FOOD-ENERGY-WATER (FEW) IN ETHIOPIA : *focusing on policy and strategy*

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FEW Nexus: Looking into the Future

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Policy Studies Institute (PSI) of Ethiopia

- **Overview:** The *Policy Studies Institute (PSI)* is a prominent Ethiopian research organization focused on socio-economic and policy research to support evidence-based decision-making.
- **Key Functions:**
  - **Research Areas:** Economic development, agriculture, governance, industrialization, and social policy.
  - **Policy Influence:** Provides data-driven recommendations to government, NGOs, & international partners.
  - **Capacity Building:** Trains researchers and policymakers in data analysis and policy formulation.
  - **Consultancy services:** to government agencies, NGOs, and international partners, providing data-driven insights for policy formulation and program implementation.
- **Notable Work:** Conducted many studies in collaborates with institutions like the World Bank, UNDP, and Ethiopian ministries.
- **Visual Idea:** 🏛️ **PSI Ethiopia** → 📊 Research → 🏛️ Policy Impact → 🌍 Sustainable Development

1. Background and Context

- Ethiopia's development is **deeply intertwined with its natural resources**, particularly food, energy, and water (FEW) systems.
- The country's food systems rely heavily on rain-fed agriculture, making them vulnerable to climate variability and droughts.
- Energy production is dominated by hydropower, which faces challenges from water scarcity and climate change, impacting electricity reliability.
- Water resources are unevenly distributed, with access to clean water remaining a critical issue in rural and urban areas alike.

1. Background and Context

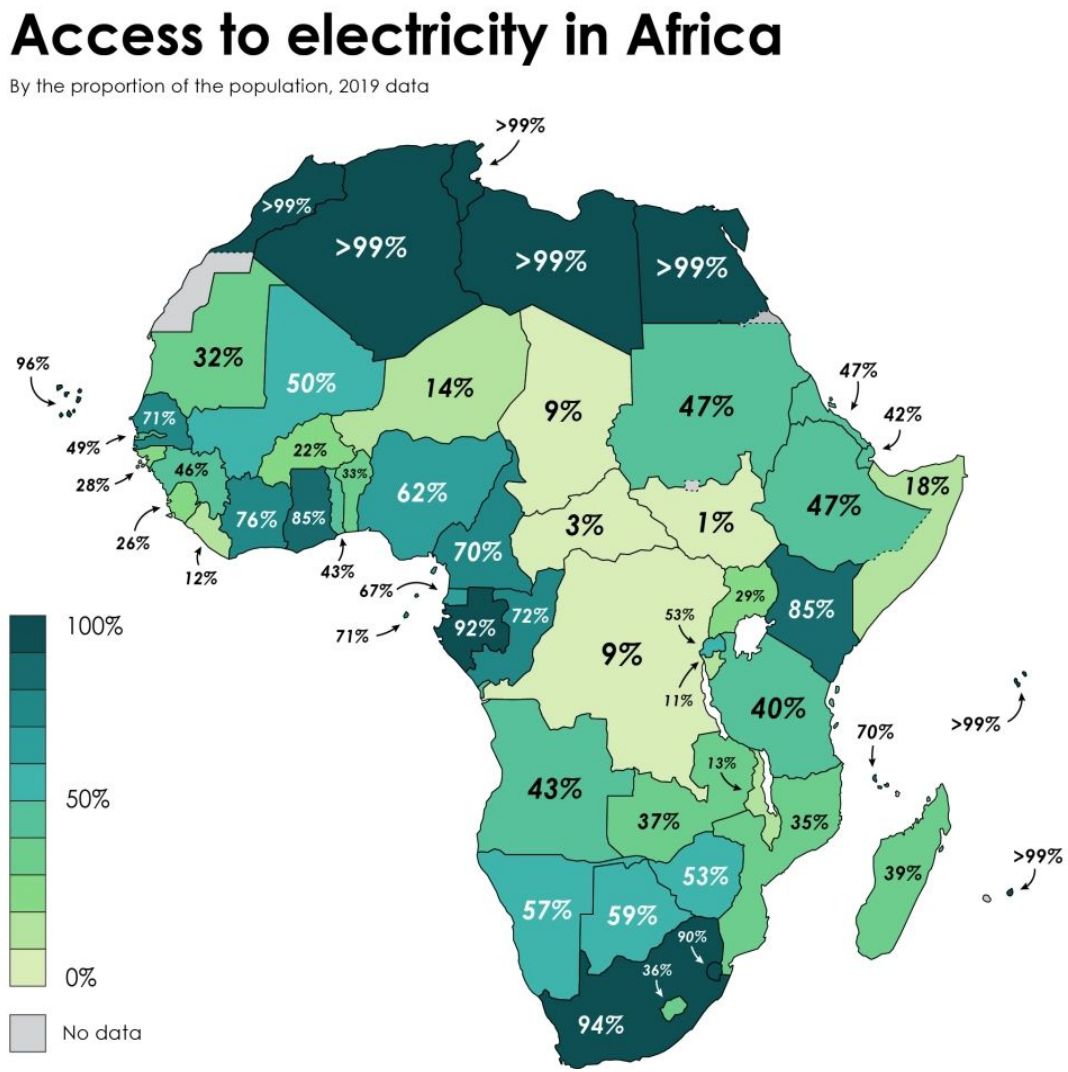
- **Food Security and Agricultural Dependence**: Agriculture, which employs over 70% of the population and contributes 34% of GDP). ≈ 85% of agricultural production relies on seasonal rainfall, with only ≈10% of arable land under irrigation, leaving crop yields susceptible to climate variability (FAO, 2022).

- Issues on dependence exacerbates food insecurity, particularly during recurrent droughts, which disrupted harvests and left millions in need of emergency aid (USAID, 2023). The sector's low productivity is further compounded by limited access to modern inputs, land degradation, and smallholder farmers' financial constraints.

- Climate change intensifies these challenges, with projections indicating rising temperatures, erratic rainfall, and more frequent extreme weather events (IPCC, 2022).

1. Background and Context

- **Energy Production and Hydropower Dominance**: Ethiopia's energy sector is characterized by an overwhelming reliance on hydropower, which accounts for approximately 90% of the country's electricity generation (Gebreluel, 2014).
- The hydropower-dominated energy system creates complex interdependencies with Ethiopia's food and water security.
- Moreover, large-scale hydropower projects often compete with agricultural water needs, as seen in controversies surrounding dam-induced changes to downstream irrigation patterns and ecosystems (Bekele et al., 2020).



IEA, 2019

1. Background and Context

- **Water Resources: Availability, Demand, and Stress:** Ethiopia is often described as the "water tower of Africa“, possessing significant freshwater resources from its twelve major river basins.
- The problem is **utilization**

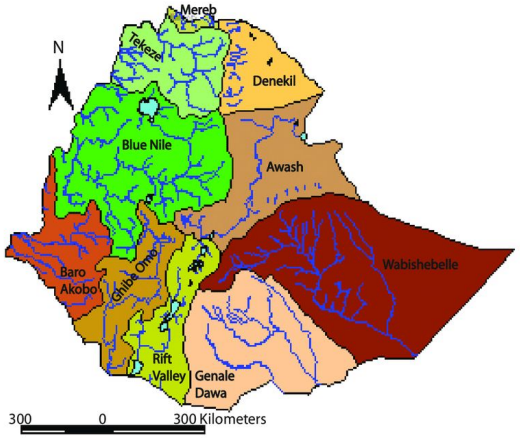


Table 1. Summary of the total annual renewable water potential , along with key features

Resource Type	Volume (BCM/year)	Notes
Surface Water (Rivers)	~122 BCM	70% from Nile Basin.
Lakes & Reservoirs	~250 BCM (storage)	Lake Tana holds ~30 BCM.
Groundwater	2.6–6 BCM	Underutilized.
Total Renewable	~125–128 BCM	Per capita: ~1,500 m^3/year (water-stressed if <1,700).

1. Background and Context

Water Resources: Availability, Demand, and Stress

- However, the country's water wealth is unevenly distributed both geographically and temporally, with spatial disparities leaving some regions water-abundant while others face chronic scarcity (Haileslassie et al., 2016).
- Seasonal rainfall variability compounds these challenges, as approximately 80% of precipitation falls during the June-September creating alternating flood risks and dry period shortages (Conway & Schipper, 2011).
- Mounting demand across sectors create complex trade-offs in water allocation decisions that current sectoral policies often fail to address holistically

2. Why the FEW nexus?

- Food production, energy generation, and water availability are inextricably linked, requiring coordinated governance **policy** to avoid trade-offs and maximize synergies (Hoff, 2011) and to avoid growing stress due to competing demands
- This hydrological paradox abundance alongside inaccessibility forms a critical tension point in Ethiopia's FEW nexus, where water availability fundamentally constrains both agricultural productivity and energy generation capacity.

2. Why the FEW nexus?

- Large-scale irrigation and dam projects that aimed to boost food and energy security but risk disrupting downstream ecosystems and transboundary water-sharing agreements (Wheeler et al., 2020). Balancing these competing needs **requires policies that account** for cross-sectoral impacts.
- **Climate change exacerbates** Ethiopia's FEW challenges, with rising temperatures, erratic rainfall, and extreme weather events threatening stability (IPCC, 2022). Projections indicate worsening droughts and floods, which could reduce crop yields by 20–50% in some regions by 2050 (Funk et al., 2012).
- **Hydropower generation** is also at risk and need the right **policy**, as declining river flows and sedimentation reduce dam efficiency (Gebremeskel et al., 2019). Strengthening resilience through climate-smart agriculture, diversified energy sources, and improved water storage is critical for long-term sustainability.




3. Methodology

The study employed a mixed-methods approach combining policy document reviews, case study analysis, and comparative benchmarking with other African countries.

- First, a comprehensive review of Ethiopia's key policies and strategies of the three sectors; water, energy and food (agriculture).
- To complement the policy analysis, an in-depth case studies of FEW interventions in Ethiopia were evaluated, including solar irrigation, agrovoltaics, and wastewater reuse.
- Finally, the study also incorporated a comparative analysis of FEW governance models from Rwanda, South Africa, Morocco, Kenya, and Namibia. These countries were chosen for their innovative approaches to nexus coordination, financing, and community engagement.

Table 2. Ethiopian dams, irrigation potential and key challenges

Dam Name	Capacity (MW)	River Basin	Current Energy Role	Irrigation Potential	Key Challenges	References
Grand Ethiopian Renaissance Dam (GERD)	6,450	Blue Nile (Nile)	Future backbone of national grid (15,000 GWh/year)	Can irrigate 500,000+ ha	Transboundary tensions; sedimentation	(BBC, 2020; MWIE, 2021)
Gibe III	1,870	Omo-Gibe	Powers industries & exports to Kenya	Supports 150,000 ha sugarcane farms	Downstream ecosystem damage	(International Rivers, 2015)
Gibe II	420	Omo-Gibe	Grid stability	Minimal (used for sugar plantations)	High evaporation losses	(EEP, 2018)
Gibe I	184	Omo-Gibe	Local grid support	Limited	Aging infrastructure	(EEP, 2018)
Tekeze	300	Tekeze	Northern grid stability	Limited use	Siltation; drougt	(World Bank, 2010)
Koka	43	Awash	Historic power source	Irrigates 7,000 ha (vegetables)	Pollution from farms	(Awulachew et al., 2008)
Fincha	134	Fincha	Supports central grid	Irrigates 10,000 ha (sugarcane)	Overused watershed	(FAO, 2015)
Amerti-Neshe	97	Dedessa	Local supply	Potential 5,000 ha	Low reservoir capacity	(MoWIE, 2019)
Genale Dawa VI	254	Genale-Dawa	Powers Somali Region	Potential 20,000 ha	Drought-prone area	(AfDB, 2020)
Melka Wakena	153	Shebelle	Southern grid support	Small-scale irrigation	Siltation issues	(EEP, 2019)
Tana Beles	460	Blue Nile	Grid expansion	Feeds 140,000 ha	Water diversion conflicts	(MoWIE, 2021)
Chemoga Yeda	25	Blue Nile	Micro-grid support			

Major Dams Irrigation, Food Production Potential in Ethiopia's

1. Current Irrigation & Food Production

- Large-Scale Irrigation: **Fincha & Koka and Tana Beles**:
- Localized Irrigation: Smaller dams

2. Untapped Irrigation Potential, GERD, Genale Dawa, Gibe II & Others:

3. Key Challenges Limiting Food Production

- **Transboundary Conflicts**: GERD's tensions with neighboring countries may delay irrigation benefits.
- **Environmental Trade-offs**: Gibe III's downstream ecosystem damage (Omo River) threatens indigenous livelihoods and Koka's pollution from farm runoff reduces water quality.
- **Climate Risks**: Drought vulnerability (Tekeze, Genale Dawa VI) and siltation (Melka Wakena, Tekeze) reduce reliability.
- **Infrastructure Gaps**: Aging dams (Gibe I) and low reservoir capacity (Amerti-Neshe) limit scalability.

Ethiopia's Energy Resource Potential vs. Exploitation

- **Untapped Renewable Energy Potential**
  - **Hydropower**: Only 4.2 GW exploited out of 45 GW potential (~9% utilization).
  - **Wind**: Vast potential (1,350 GW), but only 0.324 GW harnessed (<0.1% utilization).
  - **Solar**: High daily irradiance (4–6 kWh/m²), but no utility-scale exploitation reported.
  - **Geothermal**: 67 GW potential, yet minimal development (0.0073 GW exploited).
- **Biomass Dominates Current Use**
  - **Wood**: Half of the potential exploited (560 million tons of 1,120 million tons), reflecting heavy reliance for cooking/heating.
  - **Agricultural residues**: 6 million tons used out of 15–20 million tons potential, indicating room for bioenergy expansion.
- **Fossil Fuels Remain Untapped**
  - **Coal, Natural Gas, and Oil**: No exploitation reported despite significant reserves (300M tons coal, 116B tons gas, 253M tons oil), likely due to policy focus on renewables.

Table 3. Information on existing energy potential resources of each type and how much has been exploited so far (Kena et al 2021)

Resources	Unit	Exploitable Potential	Exploited Amount
Hydropower	GW	45	4.2
Wind	GW	1350	0.324
Solar/day	kWh/m2	4-6	0
Geothermal	GW	67	0.0073
Wood	Million tons	1120	560
Agriculture	Million tons	15-20	6
Coal	Million tons	300	0
Natural Gas	Billion tons	116	0
Oil Crude	Million tons	253	0

Table 4. Wind and Solar Energy in Ethiopia

Plant Name	Type	Capacity (MW)	Location	Status	Developer/Operator	Key Notes	References
Ashegoda Wind Farm	Wind	120	Tigray Region	Operational (2013)	Vergnet (France) & EEP	Ethiopia's first large-scale wind farm	(Reuters, 2013)
Adama I Wind Farm	Wind	51	Oromia Region	Operational (2012)	CGCOC (China) & EEP	Phase 1 of Adama wind projects	(EEP, 2015)
Adama II Wind Farm	Wind	153	Oromia Region	Operational (2016)	CGCOC (China) & EEP	Expanded capacity from Adama I	(China Daily, 2016)
Aysha Wind Farm	Wind	120 (planned)	Somali Region	Planned	UAE's AMEA Power	Expected by 2025	(AMEA, 2022)
Mesobo-Harena Wind	Wind	100	Tigray Region	Under Construction	Siemens Gamesa & EEP	Delayed due to conflict	(Bloomberg, 2021)
Tigray Wind Farm	Wind	400 (planned)	Tigray Region	Proposed	Danish Energy Agency	Feasibility studies ongoing	(DEA, 2020)
Gad Wind Farm	Wind	250 (planned)	Somali Region	Planned	Enel Green Power	Part of renewable expansion	(Enel, 2023)
Scaling Solar PV	Solar	250	Afar Region	Operational (2020)	ACWA Power (Saudi Arabia)	Part of IFC's Scaling Solar program	(IFC, 2020)
Metehara Solar Farm	Solar	100	Oromia Region	Operational (2020)	Enel Green Power	One of Africa's largest PV plants	(Enel, 2020)
Dicheto Solar	Solar	125 (planned)	Afar Region	Planned	IPP (International consortium)	Under negotiation	(MoE, 2023)
Welenchiti Solar	Solar	50	Oromia Region	Under Construction	Ethiopian Electric Power	Grid-connected by 2024	(EEP, 2022)
Gode Solar	Solar	60	Somali Region	Proposed	African Development Bank	Part of desert solar initiative	(AfDB, 2021)


Water
POLICY
VS
Strategy
Food
Energy

Table 5: Categorizing Ethiopia's key policies related to the Food, Energy, & Water (FEW) Nexus by sector, with their nexus relevance

Sector	Policy/Strategy	Year (Revised)	Key Focus	Nexus Relevance
Food/ Agriculture	New Agriculture and Rural Development policy	2024	Smallholder farmers, pastoralists, and commercial farms	Integrated approach to rural development, recognizing the interconnectedness of agriculture, rural livelihoods, and broader development
	Food and Nutrition policy	2018	Food and nutrition	Connects agriculture and health outcomes
	National Nutrition Strategy	2008 (2016)	Food security and nutrition improvement	Connects agriculture to health outcomes
	Climate-Resilient Green Economy (CRGE) Strategy	2011	Sustainable agriculture + climate adaptation	Explicit FEW integration (e.g., solar irrigation)
	Food System Transformation Pathway	2021	Sustainable food production (UN commitment)	Aligns with SDGs on hunger and resource use
	National Agricultural Extension Strategy	2016	Modern farming techniques	Water/energy efficiency in agriculture
Energy	National Energy Policy	1994 (2012)	Renewable energy (hydro, wind, solar) + rural electrification	Hydropower-irrigation trade-offs
	Renewable Energy Proclamation (No. 1187/2020)	2020	Private-sector investment in renewables	Supports agrovoltaics and solar pumps
	Energy Sector Development Plan	2013-2037	Universal electricity access (hydropower focus)	Grid expansion for irrigation
	Biofuels Development Strategy	2007	Reduce fossil fuel reliance	Competes with food crops for land/water
	National Electrification Program (NEP 2)	2019	100% electrification by 2025 (+ off-grid solar)	Links energy access to agricultural productivity
Water	National Water Policy	1999 (2001)	Equitable access, irrigation, and hydropower	Foundation for FEW coordination
	Water Resources Management Proclamation (No. 197/2000)	2000	Water allocation and environmental protection	Governs transboundary water use
	National Irrigation Policy	2011	Large-scale and smallholder irrigation	Direct agriculture-energy-water linkage
	Water Sector Strategy	2016	Sustainable water use (agriculture/industry/domestic)	Climate-resilient water planning
	One WASH National Program	2013	Water, sanitation, and hygiene (WASH)	Links water quality to food safety
Cross-Sectoral	Home Grown Economic Reform	2019 to date	Integrated agriculture, energy, water approaches	Early nexus thinking in national planning
	National Adaptation Plan (NAP)	2019	Climate risks in FEW sectors	Drought/flood resilience for dams and farms
	10-Year Development Plan	2021-2030	Sustainable resource management + ++	Explicit FEW synergies (watershed-energy-griculture links)
	Sustainable Land Management Program	2008	Combats land degradation	Protects water sources and soil for agriculture

Limitations of the Current Policies

1. **Sectoral Fragmentation & Weak Coordination:** Despite cross-sectoral strategies (e.g.,HGER, 10-Year Development Plan), implementation remains siloed, with limited institutional mechanisms for FEW integration. E.g. Hydropower expansion (Energy Policy) may conflict with irrigation needs (Water Policy) without clear trade-off management.
2. **Trade-offs Not Fully Addressed:** Biofuels Development Strategy (2007) competes with food crops for land/water, but **policies lack guidelines to mitigate these conflicts**. Large-scale irrigation (National Irrigation Policy) risks water depletion without balancing energy (pumping) and food demands.
3. **Climate Adaptation Gaps:** While CRGE Strategy (2011) and NAP (2019) address resilience, they lack localized adaptation plans for farmers/pastoralists facing droughts/floods. Solar irrigation (CRGE) is promoted, but affordability and maintenance barriers persist.
4. **Data & Monitoring Shortfalls:** Limited nexus-specific indicators to track synergies/trade-offs (e.g., how electrification (NEP 2.0) impacts groundwater use for agriculture). Weak enforcement of Water Resources Management Proclamation (2000) for transboundary water sharing.
5. **Equity & Inclusion Challenges:** Smallholders and pastoralists (New Agriculture Policy, 2024) are prioritized rhetorically but face unequal access to energy/water technologies. Gender disparities in resource access (e.g., irrigation, solar pumps) are rarely addressed.
6. **Inadequate Financing Mechanisms:** The implementation gap is further widened by disjointed budgeting processes that fail to incentivize integrated solutions.

Strategic Directions for Strengthening the FEW Nexus

1. **Institutional Innovations for Cross-Sectoral Coordination:** Ethiopia requires transformative institutional reforms to bridge existing sectoral divides in FEW governance.
2. **Technological Integration (Solar Irrigation, Agrovoltaics, etc.):** Strategic deployment of integrated technologies could revolutionize Ethiopia's FEW resource efficiency.
3. **Financial Mechanisms for Scaling Nexus-Smart Projects:** Ethiopia needs to develop innovative financing models to overcome the chronic underfunding of integrated FEW solutions.
4. **Community-Centric Approaches and Indigenous Knowledge:** Ethiopia's FEW solutions must be rooted in local knowledge systems and community governance structures to ensure sustainability and equity.
5. **Adaptive Policies for Transboundary Water Management:** Ethiopia's reliance on trans-boundary river systems, necessitates adaptive policies that balance national development priorities with regional cooperation.
6. **Scale Up Climate-Resilient Technologies:** Expand decentralized renewable energy (solar mini-grids, wind) to reduce reliance on hydropower and support irrigation. Pilot nature-based solutions (e.g., watershed restoration in SLMP) to enhance water retention for agriculture/energy.
7. **Address Trade-offs Explicitly:** Develop compensation mechanisms for resource competition (e.g., biofuel producers supporting food-insecure communities). Promote circular economy approaches (e.g., wastewater reuse for irrigation, agrovoltaics to dual-use land).

Key Takeaway!

- Ethiopia's dams currently support sugarcane, vegetables, and local crops, but vast irrigation potential remains untapped. Balancing energy needs with agricultural expansion—while mitigating environmental and geopolitical risks—is critical for food security.
- Ethiopia's FEW policies demonstrate progressive nexus thinking, but implementation gaps, trade-offs, and equity issues limit their impact. Future success hinges on stronger governance, data-driven decision-making, and inclusive climate adaptation. By addressing these challenges, Ethiopia could become a regional model for integrated FEW resource management.

THANK YOU

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