Long-term Energy-Water-Land System Modeling: A case for Ethiopia

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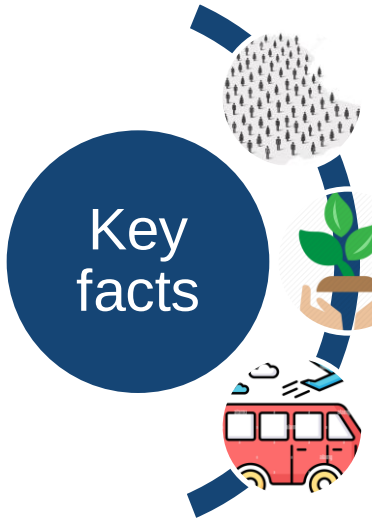
ICTP Joint Summer School for Sustainable Development

2023

Ethiopia – key facts



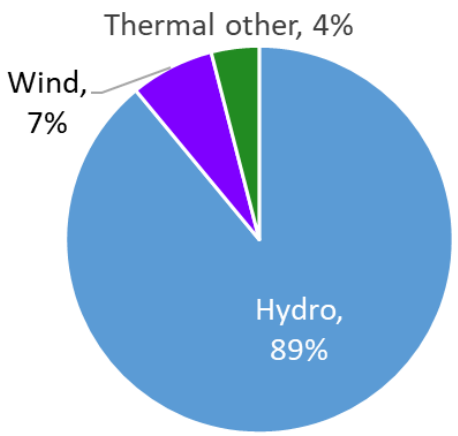
Area: 1.112 mil Km^2
Popn.: 123,379,924 (WB 2020)

Agri. land: 34%
Forest: 15.1%
Marginal: 20.9%

Transport: 99.8% imported fossil fuel
From all import expenditure: 10-14%

Energy –

Installed capacity: **4.9 GW**



Source: https://www.whereig.com/ethiopia/

Context and Challenges

- Power sector - **poor energy mix**.
  - Over-reliance on **hydropower**.
- Ambitious **biofuel strategy**.
- Dirty transport sector (**fossil based**).
- Increasing **land degradation**.
- How to utilize marginal land for **potential value** prodcution – **biofuel**?

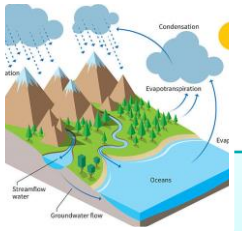
Ethiopia – Simplified Reference CLEWs Diagram

Elec. demand

ENERGY

- Hydropower
- Wind
- Solar
- Biomass
- Natural gas
- Coal
- Diesel

CO_2



Public demand

WATER

- Precipitation
- Evapotranspiration
- Surface water
- Groundwater

LAND

- Agriculture
- Forest
- Built-up
- Water bodies
- Other land

Crops:

- Maize
- Teff
- Wheat
- Sugarcane --> Biofuel --> Transport

Scenarios

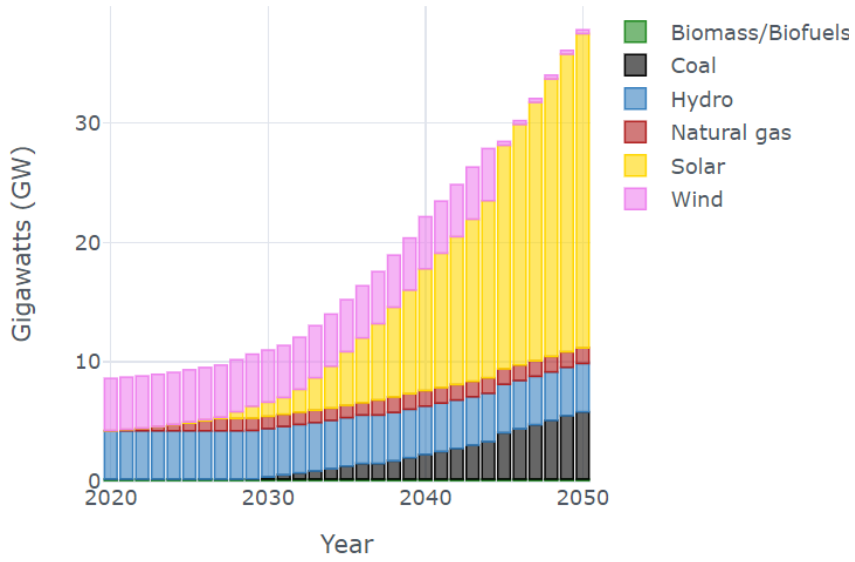
Using the CLEWs nexus model, the following scenarios were investigated:

Scenario Label	Scenario Description	Key Assumptions
BAU-mod. Baseline	▪ Cost-optimal energy-land-water benchmark model. ▪ Data: WB, FAO, national reports, CCG SDK, etc.	▪ Improved energy mix. ▪ Ensure sectoral demands.
TDC Transport De-carbonization	▪ Examine the biofuel strategy (sugar industries).	▪ Progressive biofuel blending: reaching 40% (E-40) by 2050.
IE-LE Integrated Energy-Land Efficiency	▪ Examine marginal lands use for biofuel production. (land, water and energy, CO_2 implications).	▪ Utilize 3% of the 23.2 mil. ha marginal land.

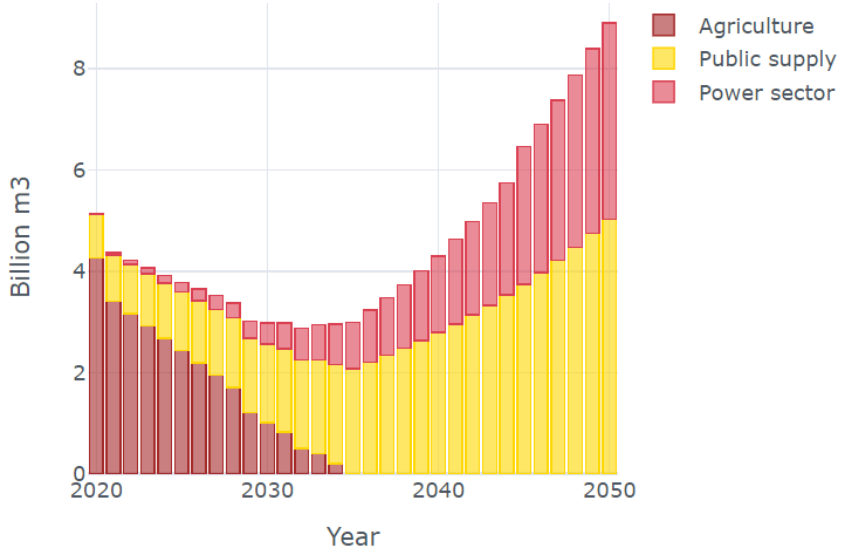
Results 1/3 – Energy Mix and Green Energy Dev't

Baseline model (BAU) –

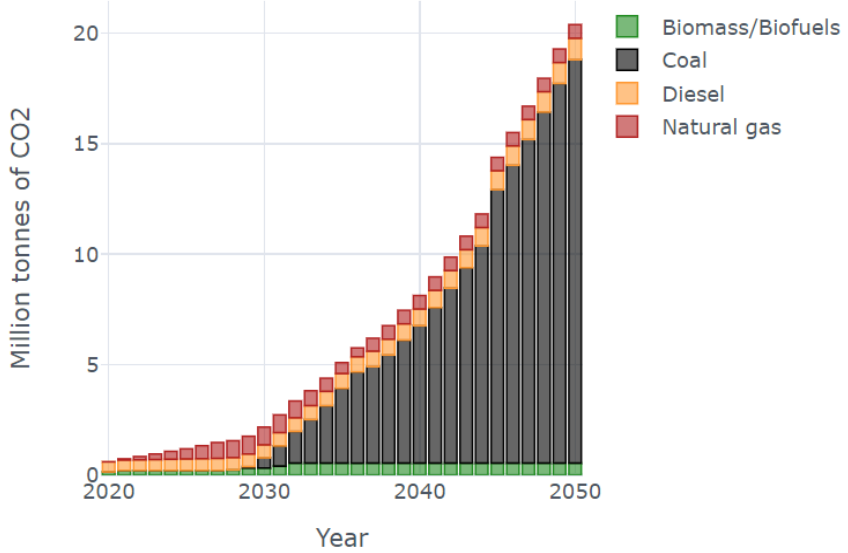
Power Generation Capacity



Water Demand



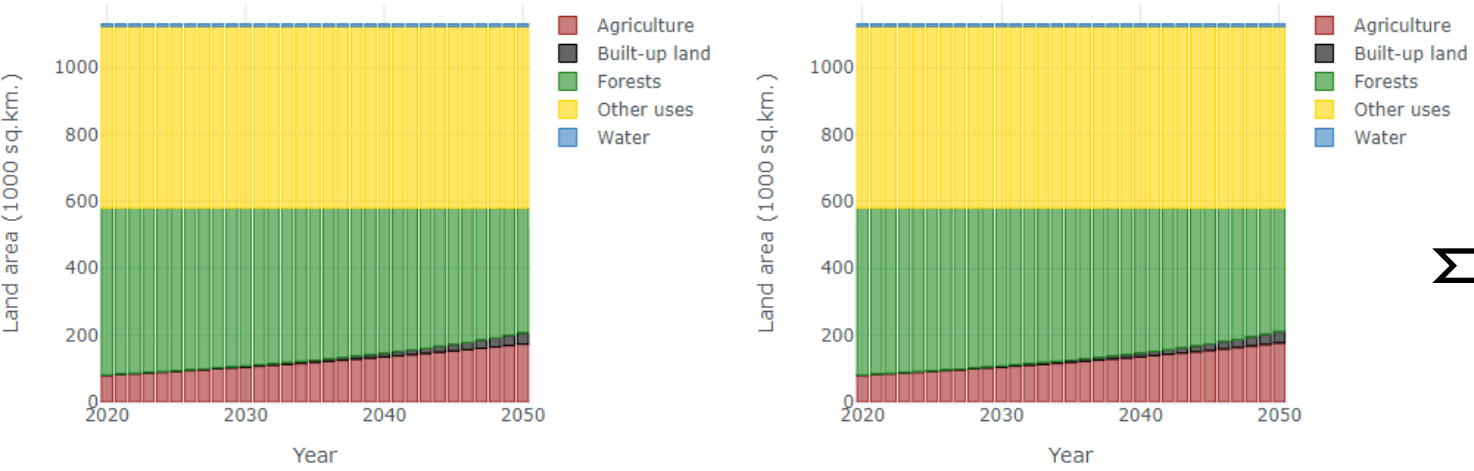
CO_2 Emissions by Source

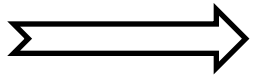


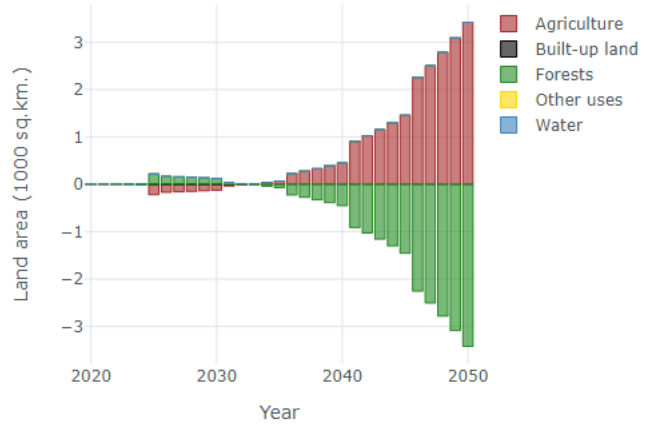
Results 2/3 – Energy Mix and Green Energy Dev't

Area by Land Cover Type

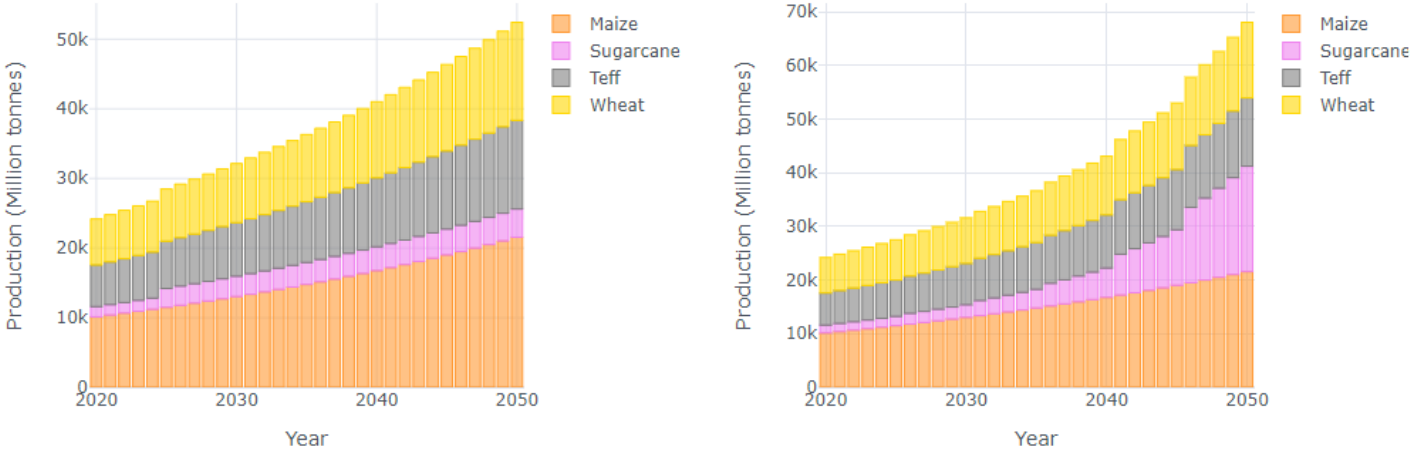
BAU vs **Biofuel (TDC)**







Crop Production

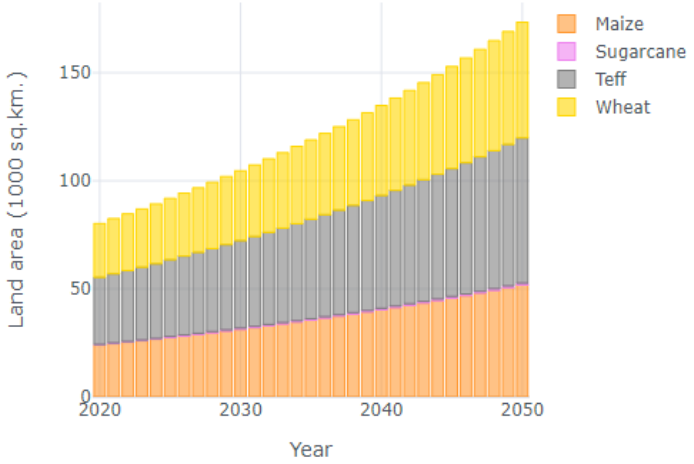


- In 2050: production needs an increase from **5 to 20 bil. tonnes**.

Results 3/3 – Energy Mix and Green Energy Dev't

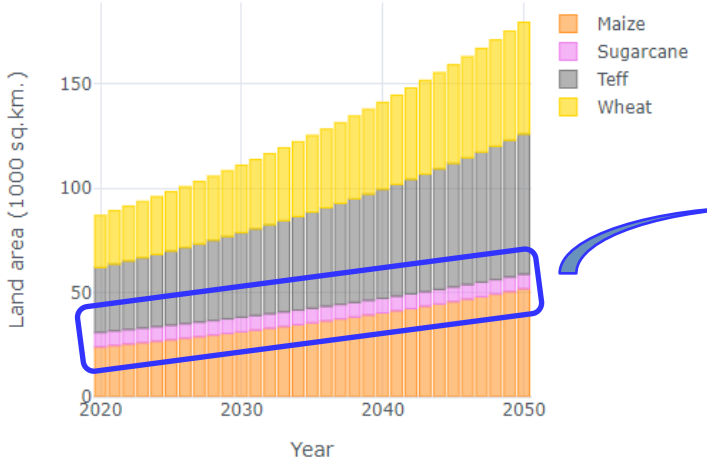
Area by Crop

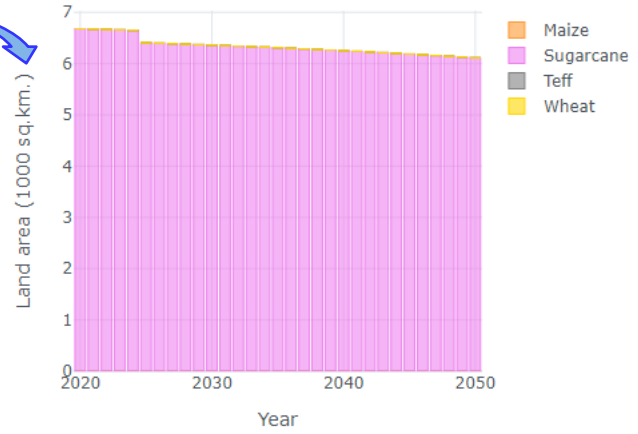
BAU



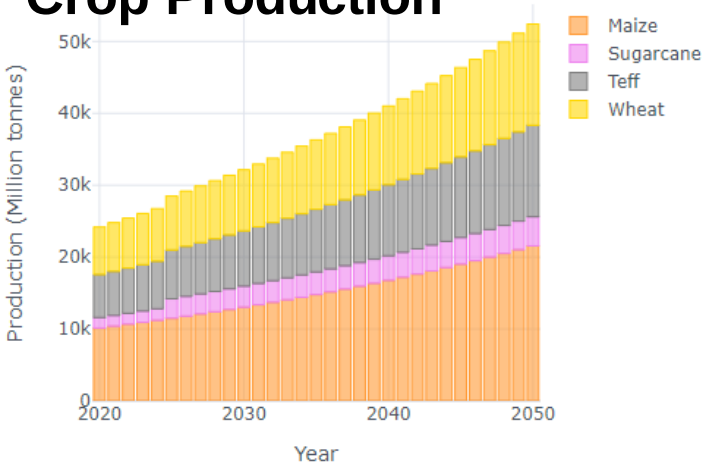
vs

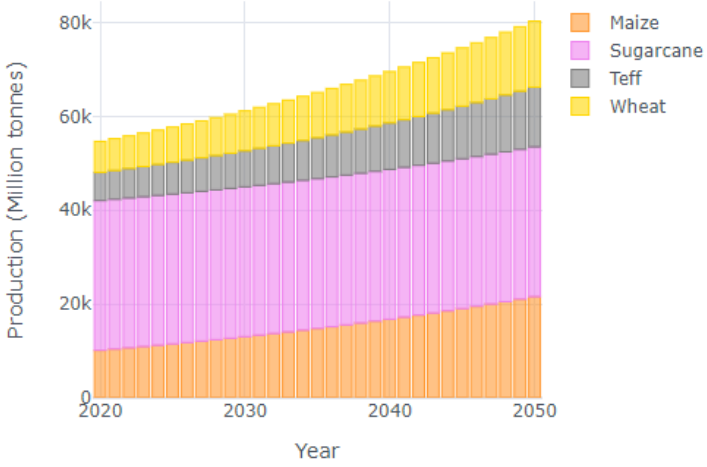
Marginal Land (IE-LE)





Crop Production





Conclusions and Policy Insights

- Improving the **energy mix** for sustainable supply and climate mitigation.

- Use of **marginal lands for biofuel** production-land use efficiency.
- Biofuel from alternative **2nd-gen feedstock,** not only from sugar processing.
- Use of marginal lands helps to operationalize **blending targets**.

- Informed policy making, **integrated modeling** (energy-land-water-climate) **CLEWs** model.

Future Work

- **Fine-tuning** and **calibrating** the CLEWs model - accurate data.
- Engaging **sectoral stakeholders** for the model development.

- Sustainable **capacity building** for experts on nexus analysis.
- Integrating **open source tools** in teaching and continuous training.

Acknowledgment

Special thanks to:

Francesco Gardumi, Kane Alexander and Leigh Martindale.

Climate Compatible Growth, IAM COMPACT[§], ICTP, AAiT.

[§]The IAM COMPACT project has received funding from the European Union's HORIZON EUROPE Research and Innovation Programme under grant agreement No 101056306.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ngiyabonga
teşekkür ederim
спасибо
dank je
thank you
gracias
tapadh leat
bedankt
hvala
mauruuru
mochchakkeram
dziękuję
go raibh maith agat
obrigado
sagolun
sukriya
kop khun krap
arigatō
takk
dakujem
grazie
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