Climate-Land-Energy-Water Nexus, Zambia

CEEEZ, UCL, KTH

Climate Compatible Growth

University Partnership:

University of Oxford · The Open University · Imperial College London · UCL · Climate Parliament · Centre for Global Equality · Loughborough University · KTH · University of Cambridge

6th Nov 2024

Agenda

- Welcome and introduction of participants – 9am
- Introduction to CCG, this project and the Climate-Land-Energy-Water nexus – 9.15am
- CLEWs nexus in Zambia – Literature review – 9.30am
- Break – 10.30am
- Policy review – 11am
- Research priorities and next steps – 12 – 1pm

Introduction – Climate Compatible Growth programme

- £95M UK FCDO-funded research programme, running 2021-2030
- Aims to help countries take a path of low carbon development, unlocking investment in green infrastructure, opening up new markets and supporting delivery of the Sustainable Development Goals
- The research is *demand-led* and *practically-orientated* to help provide solutions to economic and environmental challenges
- CCG takes a holistic and cross-sectoral approach to addressing climate compatible and inclusive growth.
- CCG research will deliver:
  - A robust and effective evidence base that informs decisions
  - Tools and decision-support frameworks
- Working with partners in Zambia, Kenya, Ghana, Vietnam, Laos. Soon Malawi and Nepal.

UK partners:

Introduction – CCG studies on energy and land

Past and ongoing research:

- Scenario development (Greening the Recovery and CCG-TRAP projects)
- Energy system modelling (OSeMOSYS modelling)
- Economic modelling (Tembo and Pye, 2024)
- Land-use change modelling
- Land governance in the context of critical minerals

Upcoming: CLEWs modelling

This project aims to: further develop a holistic understanding of the climate-energy-water-land nexus, and improve cross-sector systems thinking

This workshop aims to: enrich understanding of the key nexus issues in Zambia and policy coherence, and co-develop a research agenda

Climate – Land – Energy – Water nexus (CLEWs)

Definition:

The nexus is:

- “An intersectional concept designed to improve planning and regulatory decision-making across the three sectors.
- The nexus perspective seeks to understand the interlinkages and use systems-based thinking to frame management options for the present and future.

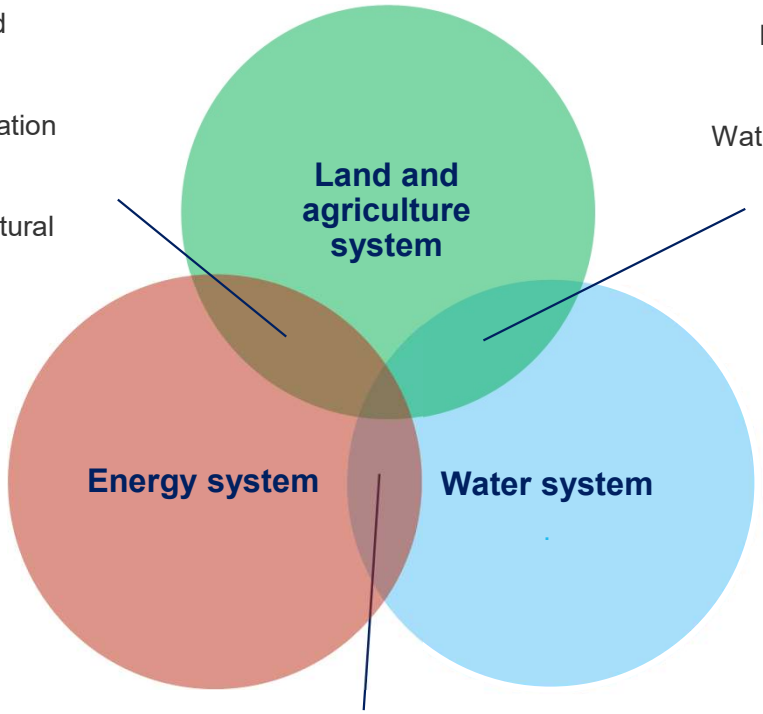
(Gomo et al, 2018)

Climate – Land – Energy – Water nexus (CLEWs)

Land for fuel production and infrastructure

Energy required for field preparation and harvest

Energy for production of agricultural inputs



Land-use impacts in the hydrological cycle

Water needs for food, feed, fuel crops and livestock (rain-fed and irrigated)

Energy for water processing

Energy for irrigation

Water for hydropower and other energy generation

GHG emissions

Precipitation, temperature changes

Climate

CLEWs nexus in Zambia: Literature and policy review

- Mapping the nexus for Zambia
  - Began with CCG Special Interest Group meeting in Feb 2024

- Review of literature
  - What are the most important issues in Zambia?
  - How do we expect them to evolve in the future due to human and environmental drivers?

- Review of land-use, water and energy policies
  - How well are the policies set up to deal with these issues?
  - Where are there policy conflicts or gaps?

CLEWs nexus in Zambia

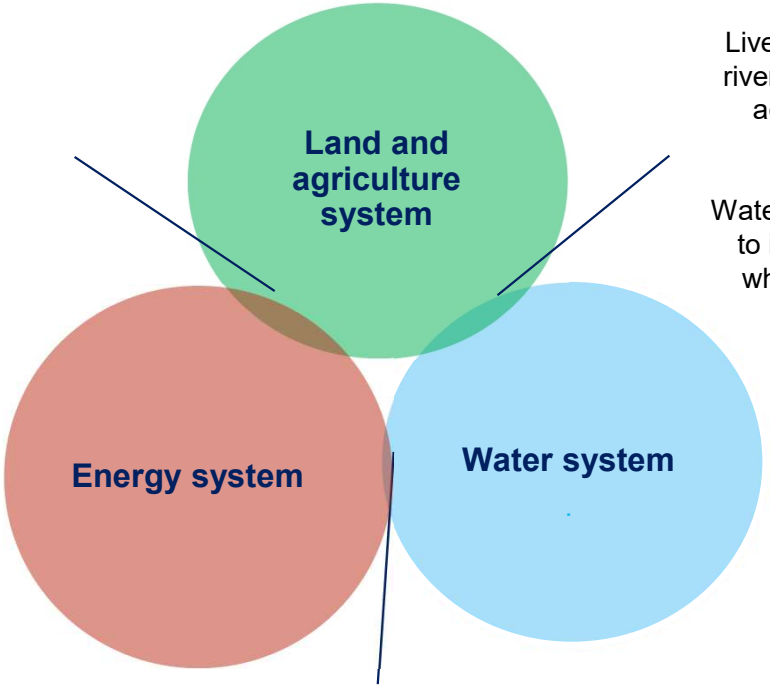
Traditional wood fuel and charcoal production cause forest degradation and loss

Energy required for mechanised agriculture and processing, production of fertilizer and pesticides

Biomass resources produced by agriculture and forestry residues

Land required for production of biofuel crops

Electricity access can affect land-use – uptake of phones increases cropland expansion and charcoal production



Deforestation changes microclimates, causes run-off, soil erosion, flooding, changes water table.

Livestock and crops near rivers can cause siltation, aquatic systems and fisheries suffer.

Water needed for irrigation, to increase crop yields, which affects cropland expansion

Energy for: wastewater processing and treatment, water pumping, and desalination

Energy for irrigation

Water for: hydropower, power plant cooling, and (bio-) fuel processing

GHG emissions from agriculture, industry, construction, fossil fuel use

Reduction in forest carbon sink

Increase in sinks due to forest regeneration

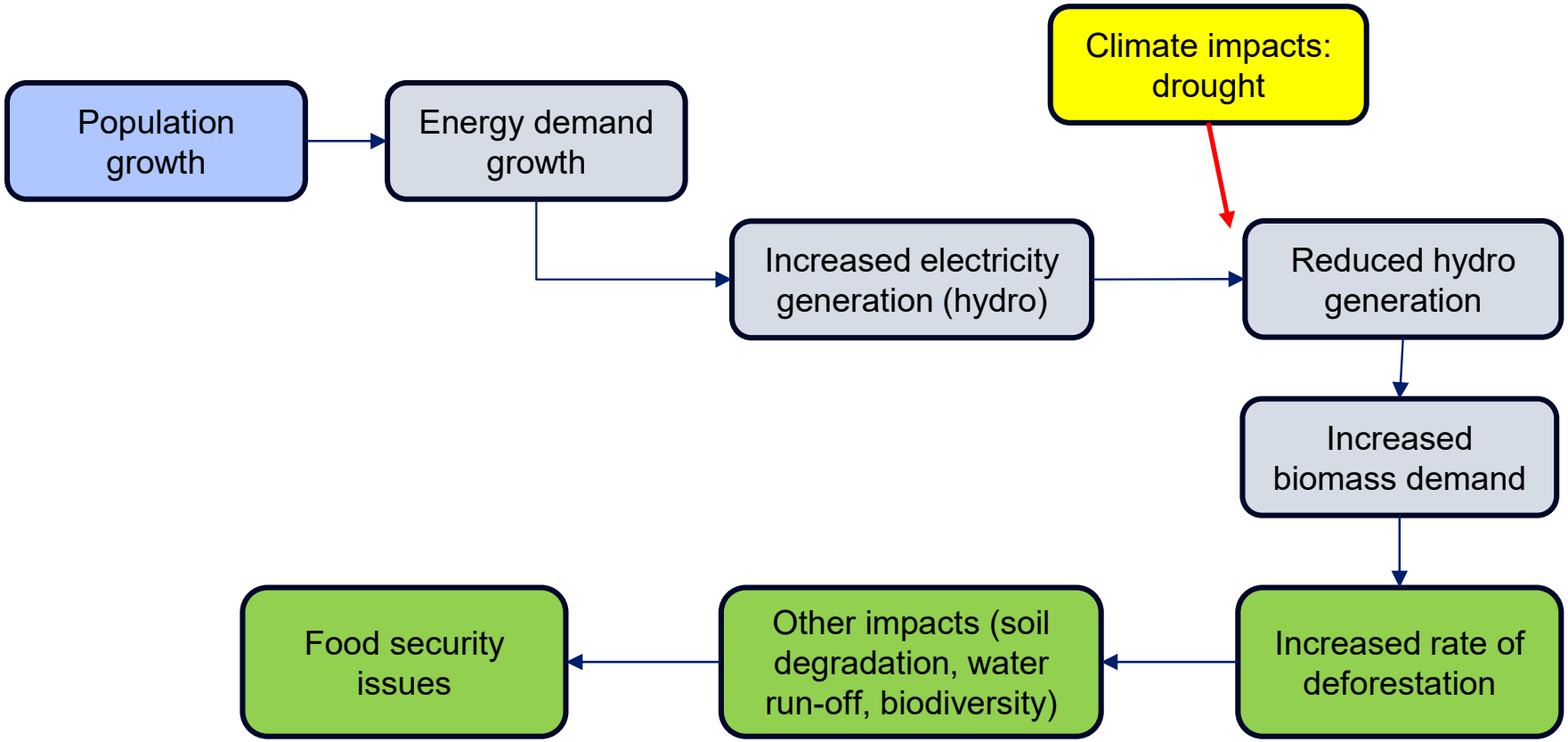
Climate

Climate impacts: hotter, drier, especially in southern and western regions. More droughts and floods.

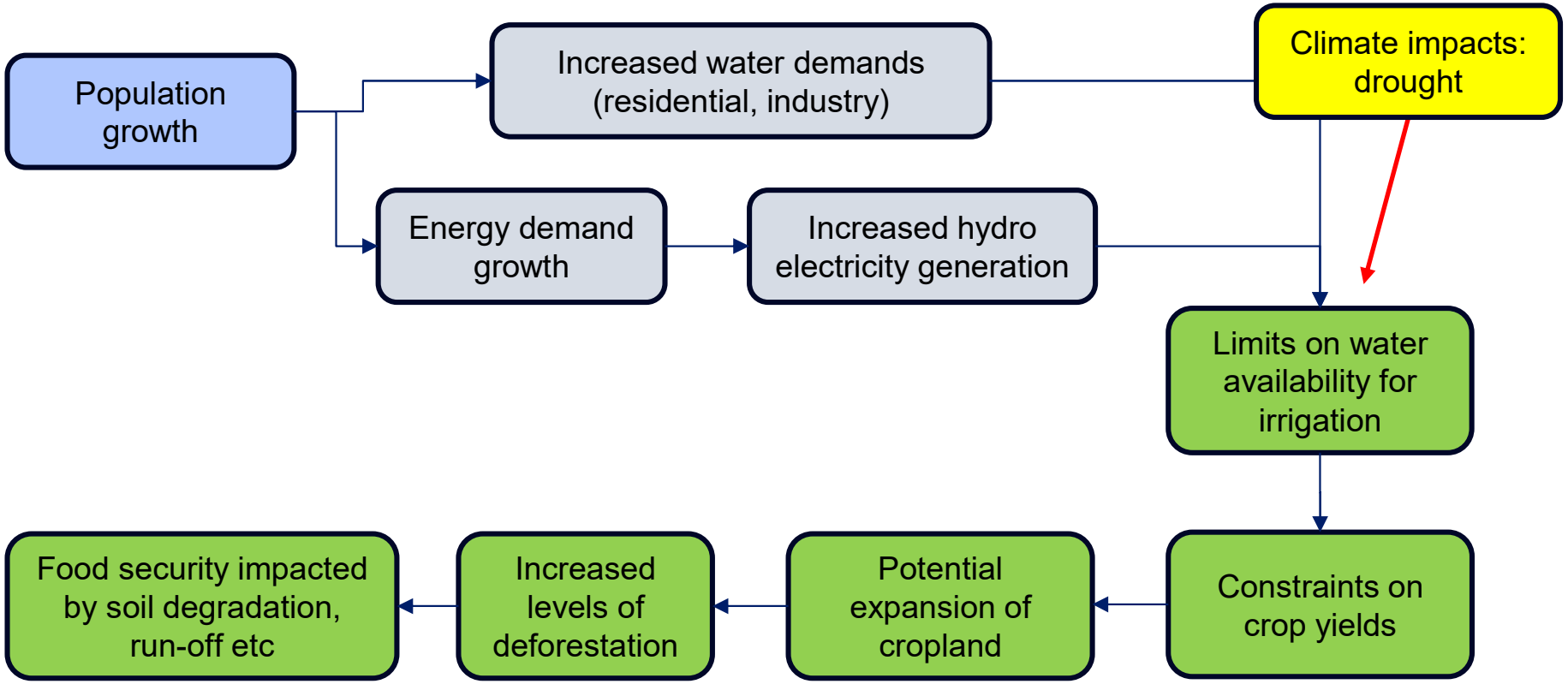
CEEEZ Centre for Energy, Environment and Engineering Zambia Limited

UCL

CLEWs nexus in Zambia: Interlinkages between systems



CLEWs nexus in Zambia: Interlinkages between systems



Literature Review

Scope

- Studies that cover one or more nexus links
- Regional focus: Zambia, a larger region including Zambia, or a sub-national region

Types of literature

- Academic journal articles
- Project reports and working papers
- A few recent Masters dissertations and PhD thesis

- It is not a fully exhaustive review… please suggest other important resources

Nexus: Water-Energy (hydro power)

Key issues:

- Climate change impacts on hydropower availability
- Focus on the Zambezi river basin
- Key sources: Yamba et al. 2011; Konga 2020; IFPRI 2023; Spalding-Fetcher et al. 2017; Payet-Burin, 2021
- Limited literature on water resource impacts of hydro (Dube & Nhamo 2023)

Research insights:

- Most literature points to a general decline in water resources for hydropower generation due to climate impacts
- There is uncertainty around the level of impact on hydro resources, and on long term decline versus seasonal variability
- Some studies further establish implications on electricity systems e.g. costs, emissions (through increased use of GenSets, Ahmed et al. 2020)

Emerging research gaps:

- Focus on strong annual-to-annual variability e.g. drought years
- Diversification of energy generation and water resource basins
- In view of hydro demand, integrating competition across other demands for water

Nexus: Water-Energy (Other)

Key issues:

- Water resource impacts of the energy sector – reservoir evapotranspiration, extraction of fuel wood (Sanchez et al. 2020)
- Increased use of irrigation enabled by rural electrification (Falchetta et al. 2022; Vinca et al. 2023)

Research insights:

- For Africa, Sanchez highlights major losses via evapotranspiration from hydro reservoirs
- On irrigation, issues of costs of this approach to increasing yields versus other yield-enhancing options
- Rural planning that incorporates different objectives around energy supply and water supply for agriculture and other uses

Emerging research gaps:

- Feasibility of yield improvement strategies associated with irrigation, and rural energy supply options; determining
- Affordability of technologies for enabling irrigation, and necessary business models

Nexus: Land-Water (Irrigation)

Key issues:

- Abstraction of water for irrigation (Tshenyengo et al. 2019; Hamududu et al. 2019)

Research insights:

- Estimates of water abstraction across 4 sub-basins varies greatly; highest in Lunsemfwa catchment
- Potential to expand irrigation depends on water resource availability (highlighting climate impacts), and competing demands; need for more water-efficient irrigation technologies

Emerging research gaps:

- Assessment of current use of irrigation (surveys and modelling)
- Irrigation potential assessment under different climate change impacts (including LT versus variability)
- Best use of irrigation given range of factors e.g. location (including water availability), needs, crop types, alternative yield enhancing strategies, costs, livelihoods)

Nexus: Land-Energy-Water (Irrigation & hydro power)

CEEEZ Centre for Energy, Environment and Engineering Zambia Limited

UCL

Key issues:

- Potential to increase hydro capacity considering irrigation (Spalding-Fetcher et al, 2014)
- Financial viability of water infrastructure projects (Payet-Burin, 2021)

Research insights:

- Increased irrigation could compromise hydropower generation in Zambia and Mozambique
- This raises important questions about water allocation and governance between sectors and countries.
- Increased energy demands could make hydro projects more financially viable

Emerging research gaps:

- Understanding regional implications of hydropower variability on interconnected grids e.g. SAPP
- Analysis of tradeoffs between energy-irrigation given uncertainty around climate impacts, energy and crop demand

Nexus: Land-Water

Key issues:

- Impact on water resources and hydrogeneration (Akialey et al 2023; Tena et al 2019)
- Anthropogenic influence on water quality (Winton et al, 2021)
- Impacts of climate change on crops (Hunter et al 2020; IFPRI 2023; Matchaya et al 2022)

Research insights:

- LULUC has negatively impacted the hydrological system, e.g. the Chongwe River Catchment.
- Agriculture, urbanization and hydropower will increase the number and extent of the hotspots of water quality degradation
- Climate change expected to negatively affect crop production, reducing the area suitable for cultivation and the productivity of existing farming areas.
- Negative impacts on livestock are projected

Emerging research gaps:

- Impacts of deforestation on freshwater and groundwater resources
- Methods to avoid increasing the hotspots of negative impacts

Nexus: Land-Energy

Key issues:

- Impacts of charcoal on forests (WISDOM 2016; CIFOR, 2020; Sedano et al, 2022)
- Land requirements for bioenergy (MoE &FAO, 2020)

Research insights:

- Charcoal impacts on forestry appear to depend on location and other activities ongoing.
- There may be sufficient sustainable potential to meet demands.
- But it can drive degradation and deforestation in hotspots.
- If crop yields increase, biofuel blending targets can be met without driving land expansion.

Emerging research gaps:

- Regeneration and agricultural activities in cleared areas following charcoal production
- Sustainable charcoal production (as well as alternatives)
- Possible land use change due to bioenergy in scenarios of agriculture
- Energy requirements for agriculture
- Interactions between energy access and land-based activities

Discussion

Breakout groups:

1. *What are the most important issues and why?*

2. *Are there particular case studies/examples of where/when the issues occur?*

With regards to:

- *Water – Energy*
- *Energy – Land*
- *Land – Water*
- *Land – Energy – Water*
- *Climate change*

Policy review

Objectives:

- Identify CLEWs components in the respective policy documents
- Understand the context of interplay and highlight existing gaps

Scope: Nine policy documents were reviewed

- Water policy (2010)
- National Policy on Climate Change (2016)
- National Energy Plan (2019)
- Land policy (2021)
- 8th National Development Plan (2022)
- Nationally Determined Contribution (2023)
- National Adaptation Plan (2023)
- Integrated Resource Plan for the Power Sector (2023)
- National Green Growth Strategy (2023)

Policy objectives

Water policy (2010)

- To optimally harness water resources for the efficient and sustainable utilization of this natural resource to enhance economic productivity and reduce poverty

National Policy on Climate Change (2016)

- To provide a framework for coordinating climate change programmes in order to ensure climate resilient and low carbon development pathways for sustainable development towards the attainment of Zambia's Vision 2030.

National Energy Plan (2019)

- To achieve an optimal energy resources utilization to meet Zambia's domestic and non-domestic needs at the lowest total economic, financial, social, environmental and opportunity cost and establish Zambia as a net exporter of energy.

Land policy (2021)

- A transparent land administration and management system for inclusive sustainable development by the year 2035.

8th National Development Plan (2022)

- To promote socioeconomic transformation for improved livelihoods through economic and job creation, human and social development, environmental sustainability, and good government environment.

Policy objectives

Nationally Determined Contribution (2023)

- To achieve an estimated total GHG emission reduction of 38,000GgCO2eq which translates to 47 percent with substantial international support, compared to 20,000GgCO2eq which translates to 25 percent, under domestic efforts with limited international support, against 2010 as a base year.

National Adaptation Plan (2023)

- To address identified risks and vulnerabilities in various sectors to enhance the country's resilience to the impacts of climate change.

Integrated Resource Plan for the Power Sector (2023)

- To provide a comprehensive, forward looking least cost plan for the development of the country's power sector, including both on-grid and off-grid. The plan is forward looking to 2050, but with a greater emphasis on the period to 2030.

National Green Growth Strategy (2023)

- To identify and sustainably develop critical economic growth model that can fast-track the attainment of the development aspirations espoused in various national policies.

Policy review and CLEWS Interplay

	Climate	Land	Energy	Water
Water policy (2010)	- Climate change is a threat to sustainable development. - Driver of increased incidences of droughts and floods. - Assessment and monitoring of potential impacts of climate change on ecosystems. - Strengthen national climate meteorological databases and monitoring networks.	- Land-use data and information for water resource planning and decision making. - Integrated land and water resources management.	- Considers water as key input resource in energy generation - Covers water allocation for Hydropower. - Transition to renewable energy technologies = Reduced fuel-wood use - saves woodlands , forests and wetlands	- Availability constraine d by climate change. - Aligns water to socio-economic development. vital resource for food, livestock, energy and aquatic life production. - Vital resource for food, livestock, energy production etc.
National Policy on Climate Change (2016)	- Impacts of climate change (droughts and rising temperatures) linked to gradual drying up of biomass. - Explores financial instruments such as weather-indexed insurance, carbon instruments to enhance resilience and cover climate related risks.	- Sustainable land use planning to protect key ecosystems and related services - Speaks to soil conservation - Land Act Cap 184- management and administration of land in Zambia	- Scaling up of alternative energy sources, energy efficiency and conservation. - Energy Regulations Act No. 23 of 2003	- The impacts of climate change on ecosystems results in reduced flows and drying up of water bodies . - Water Resources Management Act No. 21 of 2011.

Policy review and CLEWS Interplay

	Climate	Land	Energy	Water
National Energy Plan (2019)	- Climate change has negative impact on hydropower generation. - Wood fuel is most widely used fuel for cooking but unsustainable harvest and use exceeds re-growth of biomass. - Advocates for Increased systematic mainstreaming of climate change in the energy sector.	- Underscore the working relationship with line ministries for provision of land rights permits for energy projects and wood fuel regulations.	- Increase exploitation of renewable energy to diversify the energy mix. - Promotes wider usage of renewable energy technologies.	- Confirms the existence of synergy betwee n line ministry responsible for water allocation permit s and EIAs for energy projects.
Land policy (2021)	- Climate change as a driver that render land unsuitable for certain land uses due to degradation. - Relationship between property right or tenure with how land and natural resources are accessed and managed.	- Weakness and inadequacy of legal framework as reasons for failure to facilitate ownership of land rights, servicing and management - Lack of integrated land planning in customary land as a challenge.	Does not cover energy	- Reduced rainfall reduces water availability for agricultural production.

Policy review and CLEWS Interplay

	Climate	Land	Energy	Water
8th National Development Plan (2022)	- Climate change and variability led to droughts, floods and extreme temperatures. - Affect key sectors energy, agriculture and water - Emphases enhanced climate change mitigation and promotion of low carbon development in line with the NDC.	- Calls for full operationalizati on of Land Policy to address Sustainable land and forest management, Urban and land use planning.	- Focus on transition to green and renewable energy sources, increasing energy use efficiency, reducing electricity transmission and distribution losses from the national grid.	- Link droughts and high temperatures to reduced water availability and decreased hydro generation capacity. - Water quality monitoring and protection of aquifers and protected water sources.
Nationally Determined Contribution (2023)	- Practice of sustainable agriculture, Sustainable Forest management, deployment of Renewable Energy and energy efficiency technologies. - An estimated 8,370Gg CO2 eq. emissions reduction to be achieved from renewable energy interventions by 2030. - Enhanced early warning systems in key sectors.	- Emissions reduction from AFOLU interventions are estimated at 1,232Gg CO2 eq. by 2030.	- Uptake of renewable energy to increase to 10% from 3%, - add low carbon hydropower electricity supplied into the grid by 1,400 and facilitate mass deployment of energy efficient technologies	- Proposes Protection of Water aquifer and other water resources.

Policy review and CLEWS Interplay

	Climate	Land	Energy	Water
National Adaptation Plan (2023)	- Climate change poses significant risks to natural resources, socio-economic development, and livelihoods. - Recognizes the need to enhance early warning Systems, up-scaling on dissemination of climate services.	- Raises concerns over degradation of farm -lands, soils and conservation structures.	- Provision of alternative sources of energy. - Bemoan lack of capacity to integrated alternative energy sources and climate resilient construction codes.	- Enhanced climate proofing as an adaptation measure for water infrastructure. - Advocates for Integrate landscape approaches in land use planning in river catchments.
Integrated Resource Plan for the Power Sector (2023)	- Increases in extreme climate events such as flooding, landslides or wildfires that may result in direct damage to infrastructure - Emissions from coal to increase 5.9 million tonnes/yr as thermal capacity increases to approximately 1,616 MW.	- Ill-planned and ill-located renewable energy projects may threaten the nation's biodiversity and contribute to local conflicts, impeding progress in grid transformation and climate change mitigation.	- Increased uptake of renewable energy. - Hydropower sector subjected significant climate change impacts. - Increasing temperatures are expected to increase overall cooling demand.	- Indicating declines in available water for hydropower and other uses. - Decline in water availability and shifts in rainfall patterns may increase energy requirements for water transfers.

Policy review and CLEWS Interplay

	Climate	Land	Energy	Water
National Green Growth Strategy (2023)	- Climate change becoming more vision as evidenced in the mean annual temperatures. - Increased by 1.3 CO while the mean annual precipitation is decreasing at an average rate of 1.9mm per month since 1960. - Water resources are vulnerable to climate change.	- Economic growth attained using the resources sub-optimally as evidenced by the extremely low agricultural land productivity and water use efficiency. - Reduced land degradation and restore degraded areas. - Promote sustainable land conversion - Protection of ecologically sensitive areas..	- Calls for energy demand to be electrified step by step to phase out fossil fuels and reduce deforestation by shrinking the use of biomass for energy.	- Dry weather and droughts reduces availability of water for domestic use such as agriculture. - Crop failure and food insecurity.

Policy gaps

Policy	Gaps
Water policy (2010)	▪ Underscores the need to assess and monitor potential impact of climate change on ecosystems i.e. forests and wetlands. ▪ but leaves out other land uses land for energy infrastructure and settlement.
National Policy on Climate Change (2016)	▪ Requires updating to capture and reflect the current and future climate change realities as aligned in the latest National documents such as green growth Strategy.
National Energy Plan (2019)	▪ Does not reveal measures to reconfigure the existing hydropower facilities to optimize energy generation in the face of declining water resources. ▪ Silent on future coal energy projects. ▪ Promote biofuels and other renewables in the national fuel mix without linking it to land resource availability and potential GHG emissions that comes with bioenergy crop production. **Recipe for undercounting or double counting**.
Land policy (2021)	▪ Energy is not discussed.

Policy gaps

Policy	Gaps
8th National Development Plan (2022)	▪ Unclear whether the target is surface or ground water for scaling up irrigation and which pathway (decentralized, centralized or hybrid) is preferred for deploying irrigation system. ▪ Implication of either options on hydropower generation.
Nationally Determined Contribution (2023)	▪ Silent on future emissions from coal power plants expansions. ▪ Unclear whether exemptions exist for energy projects in ecologically sensitive areas seen that hydropower feasibility studies have been conducted in protected rivers and watersheds ▪ Land is not strongly perceived as a key productive resource in the development and deployment of renewable energy projects.

Policy gaps

Policy	Gaps
National Adaptation Plan (2023)	▪ Capacity gaps for planning, coordination and implementation of adaptation actions. ▪ It identifies capacity gaps in Leadership; Information, Data and Analysis; Resource Mobilization; Knowledge Management; Implementation and management; Monitoring, Learning and Accountability; Research and Technical Capacities; Social and Cultural; and Multi-Stakeholder Dialogue Processes.
Integrated Resource Plan for the Power Sector (2023)	
National Green Growth Strategy (2023)	▪ Unclear whether climate smart agriculture technologies are only earmarked for existing cropland to halt further expansion of cropland continue or both actions will happen concurrently. ▪ Measures emphasis is to Increase the share of renewable energy in the power generation mix but no interventions speaks to climate resilient hydropower generation. ▪ Absence of framework to deal with the water-energy-food-ecosystems (WEFE) nexus to help minimize tradeoffs between the WEFE.

Discussion

Breakout groups:

1. *Which of these policy gaps appear most important?*

2. *Are there policy developments are coming up which might address the gaps?*
   - Or what could be done?

3. *What are the implementation challenges for cross-sector policies?*
   - What are the forums or mechanisms for co-ordination between agencies/actors on nexus issues?
   - How could co-ordination be improved?

Research questions and priorities

Co-developing a research agenda

1. *What are the most important research questions?*
2. *What kind of research is needed e.g. modelling, qualitative…?*
3. *Who are the stakeholders?*
4. *Who is working on these topics?*

Next steps

Working paper
- Dissemination early 2025

CLEWs modelling
- Model co-development
- Trainings

Upcoming CLEWs Modelling

Aim: To provide stakeholders with policy-relevant:

- Insights into key inter-linkages and dynamics of the energy-land-water supply
- Insights into impacts of sectoral policies that go beyond the same sector
- Knowledge of risks and opportunities

What are CLEWs models:

- Techno-economic representations of real-world land-use, water, energy systems - *and their links*
- Designed to assess the role of technology change and technology choice
- Intended for long-term analysis of sustainable development issues (e.g. one or more decades)
- Highly customizable/flexible with respect to system boundaries, geographical coverage, level of detail and economic characteristics
- They can be built with OSeMOSYS, extending the boundaries of e.g. an energy system model

Initial CLEWs model

An initial model has been developed within a KTH Master thesis project – **as a discussion starter**

- Temporal scope: 8 time slices (dry and wet season, day and night peak and non-peak); 2021 - 2050
- Geographical scope: Zambia as one node
- Energy system: whole energy system represented
- Land system:
  - Agriculture: rainfed & irrigated maize, soya beans, groundnuts, sunflower, other
  - Other land covers: built area, flooded vegetation, water bodies, rangelands, forest

We are tidying up data and model files for sharing openly on Zenodo

Meanwhile please find the thesis here.

Get involved

Phase: Scoping interest in co-development of modelling and in capacity development.

Please let us know

Next modelling steps:

- Join initial CLEWs model with existing whole energy system model
- Collaborative work to edit and improve inputs with interested stakeholders
- Online session where all deploy on our laptops the updated CLEWs model

Capacity development:

- Workshop with academia and ministries (soon, led by CCG and UNDESA)
  - Introduction to CLEWs & hands on experience
  - Introduction to CLEWs – Zambia model & discussions on structure, scope, inputs, scenarios
  - Workshop to be followed by online training sessions

THANK YOU FOR TAKING PART

Stay in touch, follow up, or ask us questions at:

ceeez2015@gmail.com
jen.cronin@ucl.ac.uk
gardumi@kth.se

Climate Compatible Growth

@ResearchCcg

@ResearchCCG

@research_ccg

climatecompatiblegrowth.com

Thank you!