Integrated policy assessment and optimization over multiple SDG targets in Eastern Africa

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Introduction

- Multiple challenges related to energy in East Africa:
  - Energy access (SDG 7)
  - Health impacts (SDG 3)
  - Greenhouse gases / Climate Change (SDG 13)
  - Many more: Water, Gender, Poverty etc.

- Biomass use major source of problems:
  - East Africa as hotspot for unsustainable biomass
  - Mainly driven by cooking energy demand

- NDCs contain mix of technology policies and land policies
  - This study identifies impact of both policy types on SDG 3, 7 and 13
  - Looks at interacting effects of policies
Energy access (% people lacking access modern fuels) 
(UNDP-WHO 2009)

Pollution-related mortality (deaths per 100,000 people) 
(Smith et al 2014)

Unsustainable biomass 
(% of biomass consumption unsustainable) 
(Bailis et al 2015)
Structure

Global Change Assessment Model (GCAM)

EMISSION SETS

ENERGY CONSUMPTION

TM5-FASST

HAP Estimation

OUTDOOR

INDOOR

PREMATURE DEATHS

GLOBAL WARMING POTENTIAL (GWP)

EXPOSURE TO AIR POLLUTION

ENERGY ACCESS (TIER)

ROBUST PORTFOLIO ANALYSIS

Feedback of selected portfolios to GCAM for illustration

Scenarios
(Land and technology subsidy policies, SSPs)

Subsidy Budgets

MODELS & METHODS

SCENARIOS

DEFINITIONS FOR SDGs

INTERMEDIATE OUTPUTS

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- Global Change Assessment Model (GCAM; version 4.4):
  - Used to model future scenarios (SSP2, 3 and 5) and policies
  - Updated for Eastern Africa to better represent local reality:
    - Linking traditional biomass demand with forestry and animal sectors
    - Explicitly including consumer products as charcoal, ethanol, biogas, LPG
    - Separating Rural and Urban residential energy demand
    - Changing grid reality for rural areas and including mini-grids

- TM5-FASST: for estimating exposure to outdoor air pollution
- Historical estimation for estimating exposure to household air pollution (HAP)
  - Based on residential PM emissions from cooking and lighting

- Robust Portfolio Analysis:
  - Used for optimally allocating technology subsidies to simultaneously achieve progression in SDG 3 (Health), 7 (Energy Access) and 13 (Climate action)
  - Identifying subsidy portfolios for which the effects are robust among all SSPs
- Shares Socioeconomic Pathways:
  - SSP3: high pop, low GDP, low urbanization, low crop yields, low pollution controls
  - SSP2: medium development on all parameters
  - SSP5: low pop, high GDP, high urbanization, high crop yields, high pollution controls

- Land Policies: one scenario without and one scenario with such policies
  - Active government support for managed woodlots (in forestry areas) and agroforestry (in agricultural areas) to boost sustainable biomass output

- Technology policies: focusing primarily on cooking
  - LPG + LPG stoves
  - Biogas systems + biogas stoves
  - PV systems + electric stoves
  - Ethanol + ethanol stoves
  - Improved charcoal kilns + Improved charcoal stoves
  - Woodfuel product supply + Improved wood stoves

In scenario with land policy: Charcoal and fuelwood subsidy conditional on use of sustainable biomass
### Structure

#### MODELS & METHODS

- **Measured by estimated premature mortality caused by air pollution:**
  - Mortality as indicator of exposure to air pollution
  - Both indoor and outdoor pollution counted

- **Measured by Worldbank-ESMAP Energy access Tier framework:**
  - Based on #households with access to certain set of appliances
  - Based on #households using a certain fuel for cooking
  - Overall household tier as average of electricity and cooking tier

- **Measured by Global Warming Potential (GWP) of emissions:**
  - Including GHGs such as CO2 (x1 GWP), CH4 (x21 GWP) and N2O (x310 GWP)
  - Including indirect warming impacts from CO (x2.1 GWP) and NMVOC (x3.4 GWP)
Baseline trends

Global Warming Potential

Mt CO2-eq

- Baseline - Forestry and wood combustion
- Baseline - Agriculture and agricultural residue use
- Land policy - Forestry and wood combustion
- Land policy - Agriculture and agricultural residue use
- Baseline - Fossil fuels, industry and waste
- Baseline - Wildfires
- Land policy - Fossil fuels, industry and waste
- Land policy - Wildfires
Baseline trends

Air pollution related mortality

#deaths per 100,000 people

2010 2020 2030 2040

2010 2020 2030 2040

2010 2020 2030 2040

SSP2 SSP3 SSP5

Baseline indoor  Baseline outdoor  Land policy indoor  Land policy outdoor
Subsidy impacts

Global warming impact

Impact range based on subsidy level

Uncertainty Range based on SSP
Subsidy impacts

Impact range based on subsidy level

Uncertainty Range based on SSP
Subsidy impacts

Impact range based on subsidy level

Uncertainty Range based on SSP

Energy access impact

Million ($2015) per level of overall energy access tier

2020 - Baseline
2030 - Baseline
2040 - Baseline
2020 - Land policy
2030 - Land policy
2040 - Land policy

LPG
Biogas
PV
Ethanol
Charcoal
Fuelwood

MODELS & METHODS
SCENARIOS
DEFINITIONS FOR SDGs
INTERMEDIATE OUTPUTS

BASQUE CENTRE FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

www.bc3research.org
SSP Robust portfolio analysis: 2030 with land policy

Subsidy budget ($4.89 billion)

GHG reduction (SDG 13) 226 Mt CO2-eq (24-26%)
Mortality reduction (SDG 3) 91781 Deaths (28.5-39%)
Energy Access improvement (SDG 7) 0.285 tier increase (12.5-14.5%)

Cost per avoided ton of CO2 21.6476
Cost per avoided death 53279.12
Cost (millions) per increased energy access tier level 17147.9
Conclusions

- Synergies between SDG 3, 7 and 13 for energy policies in Eastern Africa
  - Clear synergies for subsidy policies (improving all SDGs)
  - SDG trade-offs in case of land policies (improving climate action at expense of health and energy access)

- SSP uncertainty for policy design:
  - Land policy impacts robust for all SSPs
  - Subsidy policy impacts vary significantly as SSPs diverge by 2040

- Linking land and subsidy policies:
  - Linking charcoal and fuelwood subsidy policies with land policy significantly increases their effectiveness in reducing GHG emissions
  - Impact on health and energy access unaffected by policy link

- Biogas technology most cost-effective at all dimensions
  - In GHG impact, charcoal subsidies (combined with land policy) comes second
  - In Health impact, LPG comes second
  - In Energy Access impact, PV comes second
### TABLE 6.13
Indicative Calculation of Electricity Consumption, by Tier

<table>
<thead>
<tr>
<th>APPLIANCES</th>
<th>WATT EQUIVALENT PER UNIT</th>
<th>HOURS PER DAY</th>
<th>MINIMUM ANNUAL CONSUMPTION, IN kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>TIER 1</td>
</tr>
<tr>
<td>Task lighting</td>
<td>1/2</td>
<td>4/8</td>
<td>1.5</td>
</tr>
<tr>
<td>Phone charging</td>
<td>2</td>
<td>2/4</td>
<td>1.5</td>
</tr>
<tr>
<td>Radio</td>
<td>2/4</td>
<td>2/4</td>
<td>1.5</td>
</tr>
<tr>
<td>General lighting</td>
<td>12</td>
<td>4/8/12</td>
<td>17.5</td>
</tr>
<tr>
<td>Air circulation</td>
<td>20/40</td>
<td>4/6/12/18</td>
<td>29.2</td>
</tr>
<tr>
<td>Television</td>
<td>20/40</td>
<td>2</td>
<td>14.6</td>
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<tr>
<td>Food processing</td>
<td>200</td>
<td>0.5</td>
<td>36.5</td>
</tr>
<tr>
<td>Washing machine</td>
<td>500</td>
<td>1</td>
<td>182.5</td>
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<tr>
<td>Refrigerator</td>
<td>300</td>
<td>6</td>
<td>657.0</td>
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<tr>
<td>Iron</td>
<td>1,100</td>
<td>0.3</td>
<td>120.5</td>
</tr>
<tr>
<td>Air conditioner</td>
<td>1,500</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>4.5</td>
</tr>
</tbody>
</table>

Source: Beyond Connections, energy access redefined, ESMAP
Comments & Discussion time
Method: GCAM Model

- GCAM is a **global integrated assessment model**
- GCAM links **Economic, Energy, Land-use** and **Climate** systems
- Runs in **5-year time-steps. (until 2100)**
- The GCAM core is global, written in C++, and data driven.
- Meant to analyze consequences of policy actions and interdependencies
- Extensively used in **IPCC reports** & USA Climate Change Science program