Development perspectives of Sub-Saharan Africa under climate policies

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Research Questions

- Reduction of global greenhouse gas emissions at acceptable costs requires the inclusion of developing countries into a climate policy regime
- Developing countries fear to suffer in terms of economic growth and domestic wealth
- Does climate policy slow economic growth of Sub-Saharan Africa (SSA)?
- Cheap fossil based development or transition based on renewables?
- Technology diffusion and cooperation matters
- Equity matters: Without enhancing global equity, greenhouse gas emissions will not significantly be reduced
- How to respect legitimate interest to increase material wealth and opening the way for SSA to join the global coalition that strives to stop climate change?
Research Method

• Integrated Assessment (REMIND model)

• Scenario analysis along three dimensions:
  1. Climate stabilization target
  2. Cooperation
  3. Burden Sharing

• Ex-post analysis of distributional effects
Schematic Overview of REMIND

Macro-economic Module

Energy System Module

Energy System Costs
- Fuel Costs
- Investments
- O&M Costs

Energy Transformation Technologies
- Resource and Potential Constraints

Emissions
- agriculture and forestry bioenergy supply
- GHG and aerosol concentrations; Temperature

Land-use

Climate Module
Region Definition
## Scenario Matrix

<table>
<thead>
<tr>
<th>Climate target</th>
<th>Cooperation</th>
<th>Allocation</th>
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<tbody>
<tr>
<td></td>
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<td>Equal marginal abatement costs</td>
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<tr>
<td>Baseline</td>
<td>BAU</td>
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<tr>
<td>450 ppm</td>
<td>Cooperative</td>
<td>450TAX</td>
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<td>550 ppm</td>
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<td>550TAX</td>
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<td>450 ppm</td>
<td>Non-cooperative</td>
<td>450SPA</td>
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<tr>
<td>550 ppm</td>
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<td>550SPA</td>
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Scenario Design

Technological cooperation:
• Anticipation of external effect of investment into learning technologies

Climate policy cooperation:
• global climate policy regime (uniform carbon tax/global cap-and-trade regime) vs.
• Delayed action: fragmented climate policy regime (regional carbon taxes until 2040)

Burden sharing
• Equal marginal abatement costs (= global carbon tax)
• Per capita convergence
• Cumulated population share (novel)
Above global average mitigation costs in AFR
Mitigation Costs (II) – Cooperation Dimension

AFR profits from fragmented policy regime due to low initial carbon price and higher long-term demand for biomass
Mitigation Costs (II) – Cooperation dimension

Fragmented policy regime implies more extreme intergenerational burden sharing
Mitigation Costs (II) – Allocation dimension

Substantial gains under cap-and-trade climate policy regimes with equity-based permit allocation
Decomposition of mitigation costs

GDP losses and higher energy system costs are overcompensated by revenues from biomass exports and sales of emission permits.
Global GHG Emissions

The graph shows the projected global GHG emissions from 2025 to 2100 under different scenarios.

- **BAU** (Business As Usual) scenario shows a significant increase in emissions up to 2050 before a gradual decline.
- **450TAX** scenario indicates a lower peak and a more rapid decrease in emissions.
- **550TAX** scenario has an intermediate peak and a slower decrease compared to **BAU**.

The y-axis represents Mt. CO2e/yr, and the x-axis represents the years from 2025 to 2100.
Final Energy Consumption

- 20% less final energy consumption as of 2050
- Electricity share in 2100 around 70% (40% in baseline)
Final Energy

Energy intensity

Final energy per capita

thick black line represents Sub-Saharan Africa
Primary Energy Consumption

A bar chart showing the primary energy consumption in various years (2030, 2050, 2070, 2100) under different scenarios:
- 450TAX
- 550TAX
- BAU

The chart displays the energy consumption in EJ/yr for different energy types, including:
- Geothermal
- Solar
- Wind
- Hydro
- BECCS
- Biomass
- Nuclear
- Gas w/ CCS
- Gas w/o CCS
- Oil w/ CCS
- Coal w/ CCS
- Coal w/o CCS

The bars are color-coded to represent each energy type.
Energy Investments

scenario 450TAX  BAU

variable Energy Investments Energy Investments|Elec|Solar
Energy Prices

![Graph showing energy prices over time](image)

**Variable**
- **Price Liquids (final energy)**
- **Price Electricity (final energy)**
- **GDP per capita**
Conclusions (I)

- Simulations yield mitigation costs for Sub-Saharan Africa in the range between -5% and 3%.

- Incentives of joining a global agreement can clearly be increased with a climate policy regime that includes a cap-and-trade system with an equity-based burden sharing.

- The indirect effect of emission permit sales (under a cap-and-trade system with acknowledged equity principles) and sales of biomass are likely to be larger than the direct costs of domestic GHG abatement.
Conclusions (II)

• Even with consumption gains, substantial challenges in transforming the energy system and in building up institutional capacities are implied:
  • Final energy intensity has to be reduced by 90%
  • use of coal has to be faded out completely and the electricity share has to be increased from less than 5% today to around 30% in 2050
  • Compared to the baseline scenario, final energy consumption has to be reduced by 20% in 2050 and additional energy system investments increase up to 30% until 2100
• Positive balance for the development perspectives will only hold if the financial means will be applied in a socially efficient way
• This includes investments into new energy conversion technologies, but also support for poor households which temporary may be confronted with a decline in non-energy consumption due to increasing energy prices
Thank you!
Production System