Towards a sustainable biomass energy supply for rural households in semi-arid Shinyanga, Tanzania

A cost/benefit analysis

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Introduction - Energy in Tanzania

- Traditional biomass 92% of TPES
- 10% electrification (2% rural)
- Oil import 30% foreign expenditures
- Deforestation 1.1 % per year
- Energy poverty in drylands (30% semi-arid)
- Prices fuelwood: 500 – 700 Tsh/headload

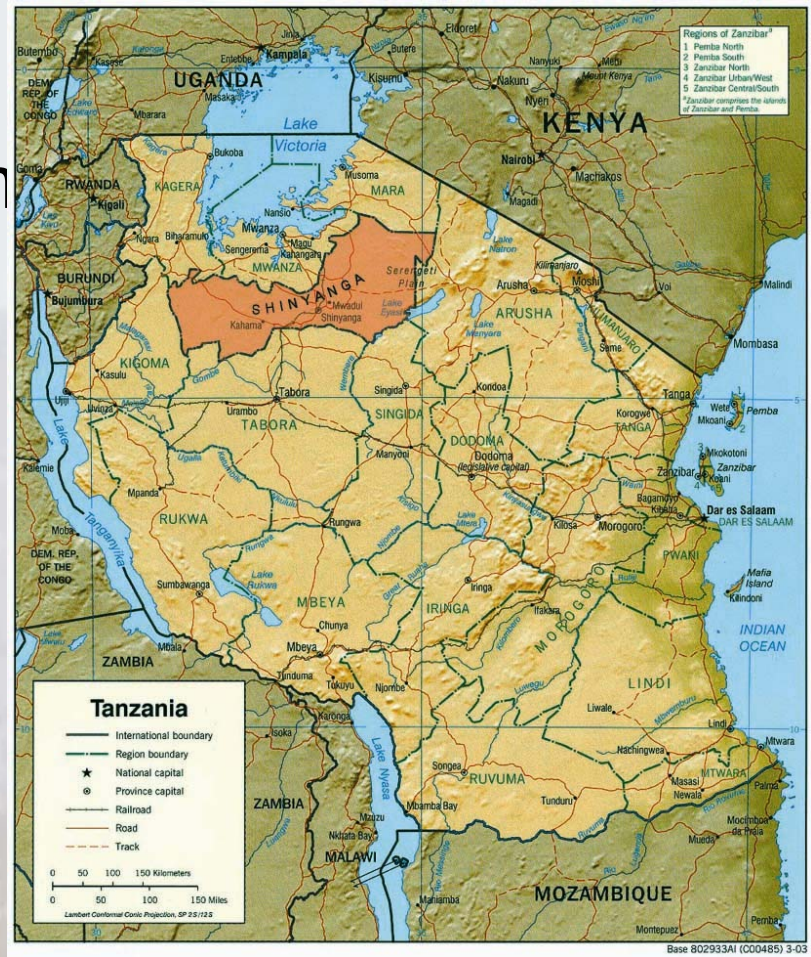
=> Sustainable bioenergy production desirable

Research objective

Compare the economic feasibility and the socio-economic impacts of three different sustainable small-scale biomass energy supply systems for rural smallholders using a cost/benefit analysis.

Case Study: East Shinyanga

- High livestock concentration
- Severe land degradation
- Low staple crop yields (maize)
- Long dry season
- Large fuelwood deficit
- No rural electricity



Three small-scale bioenergy systems

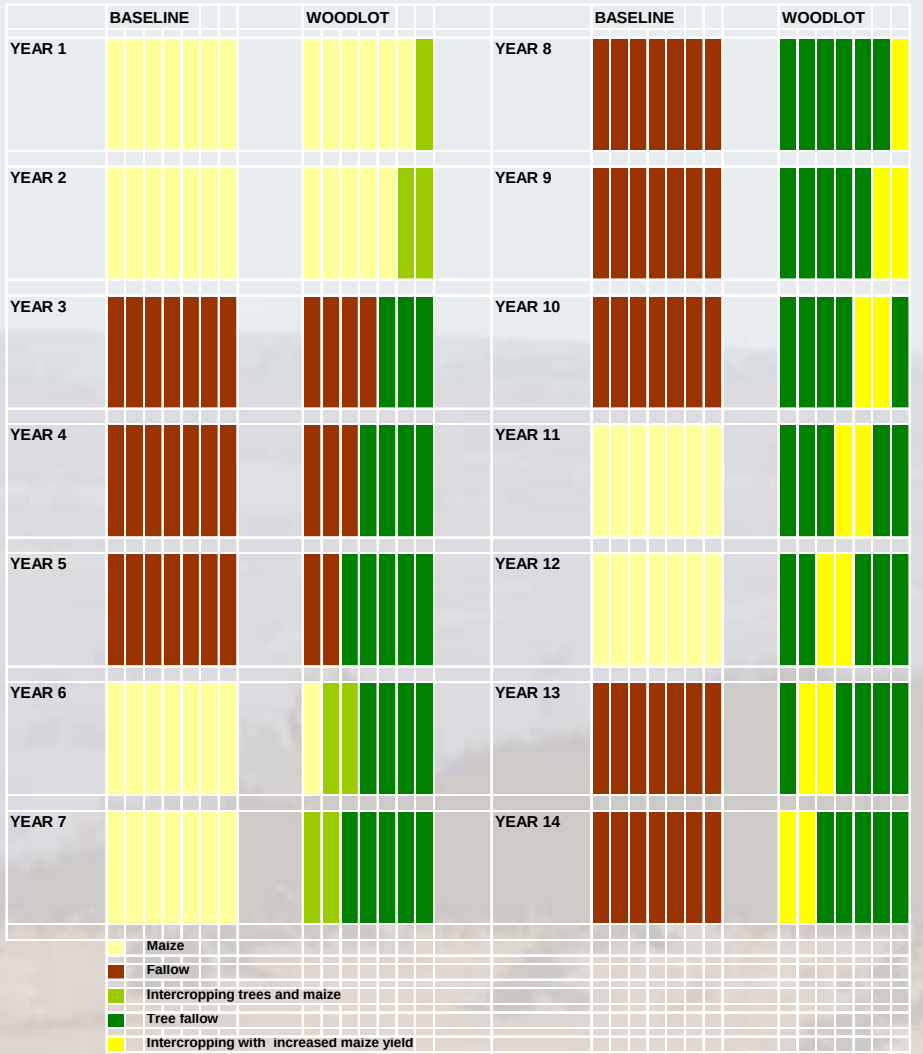
- Carbon forestry - fuelwood
- Rotational woodlot – fuelwood/charcoal
- Jatropha plantation - jatropha oil

Carbon forestry

- Small-scale CDM methodology: Max 8 $ktCO_2/yr$
- Medium scale on community land ~ 1500 ha
- Above-ground biomass increment: 2 $t_{dm}/ha/yr$
- Benefits from voluntary carbon credits
- 10% fuelwood harvest
- Indirect benefits
  - forest products, avoided deforestation, land reclamation, increased biodiversity

Rotational woodlot

- *Acacia Polyacantha*
- Mean annual biomass increment: 10 t_{dm}/ha/year
- Small-scale on agricultural land
- Intercropping with maize (also monoculture)
- Fuelwood or charcoal
- Use of leguminous fodder
- Also harvest of poles



Jatropha production

- Monoculture or intercropping
- Small-scale on agricultural land (intercropping) or degraded land (monoculture)
- Use of jatropha for several purposes possible
  - Trade of seeds, oil
  - Electricity generation
  - Soap production
  - (Heat use)

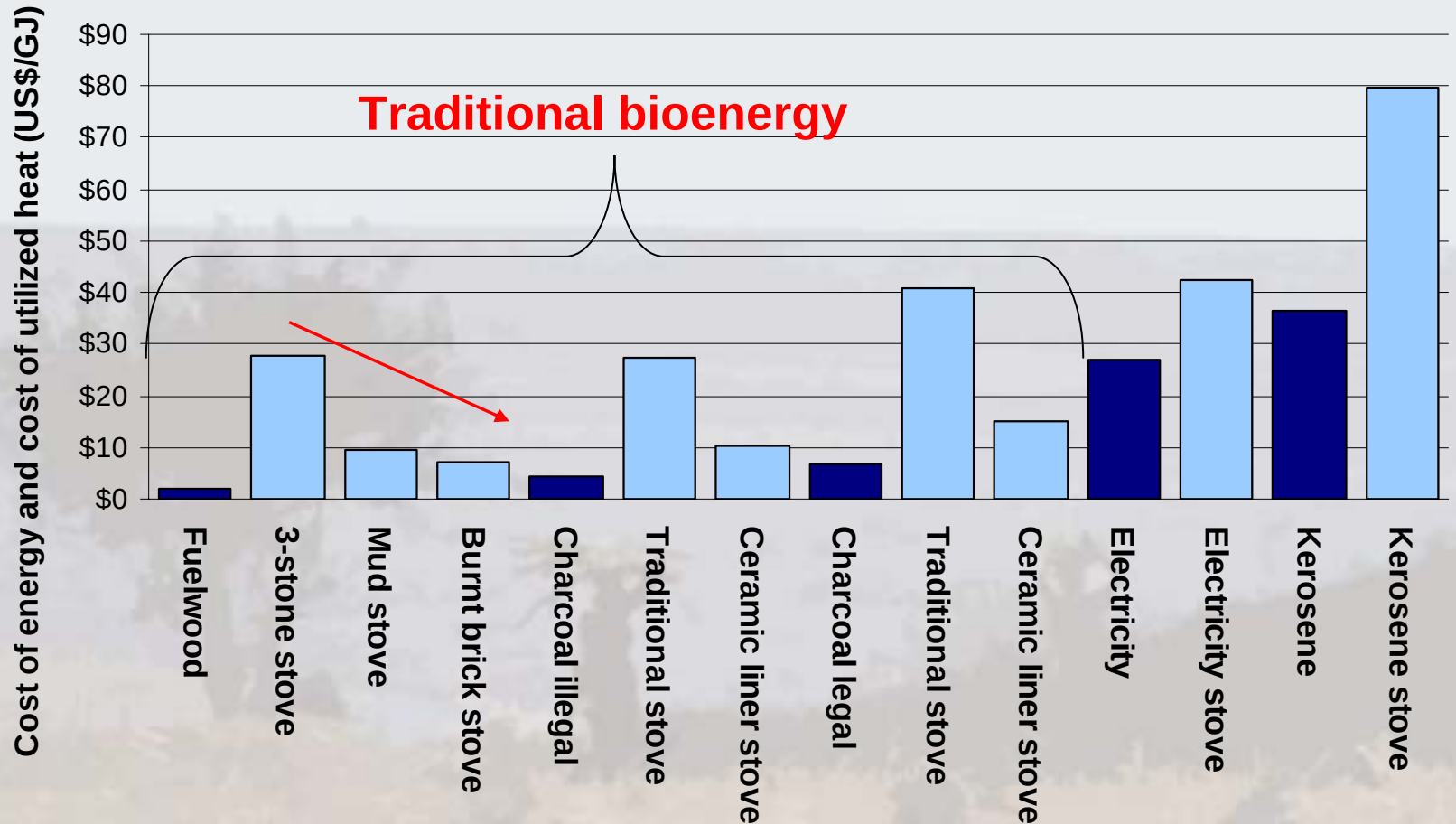
Methodology

- Cost-benefit analysis against ‘baseline’
  - Maize cropping and cattle in dry season
- Calculation of
  - NPV: US$/ha (using shadow cost of labour)
  - Return on Labour: US$/man-day
  - Cost of Energy: US$/GJ

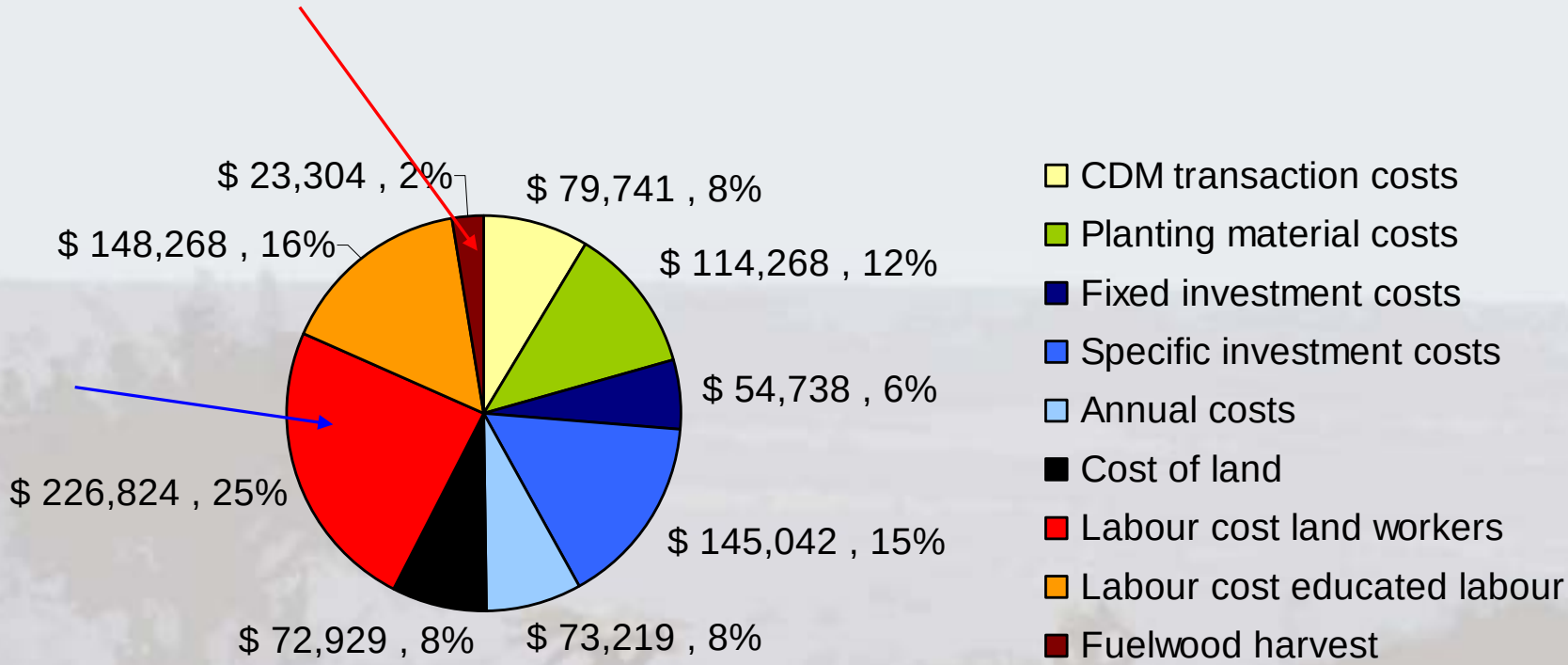
Baseline assessment

- Maize cultivation
  - Maize-fallow system: 2 years maize, 3 years fallow
- Opportunity cost of land
  - Renting price agricultural land
  - Wet/dry season ~ 34 or 16 US$//ha/season
- Shadow cost of labour - ~ US$ 1.43 /man-day
  - Return on labour (US$ 1.88 /man-day) minus opportunity costs land

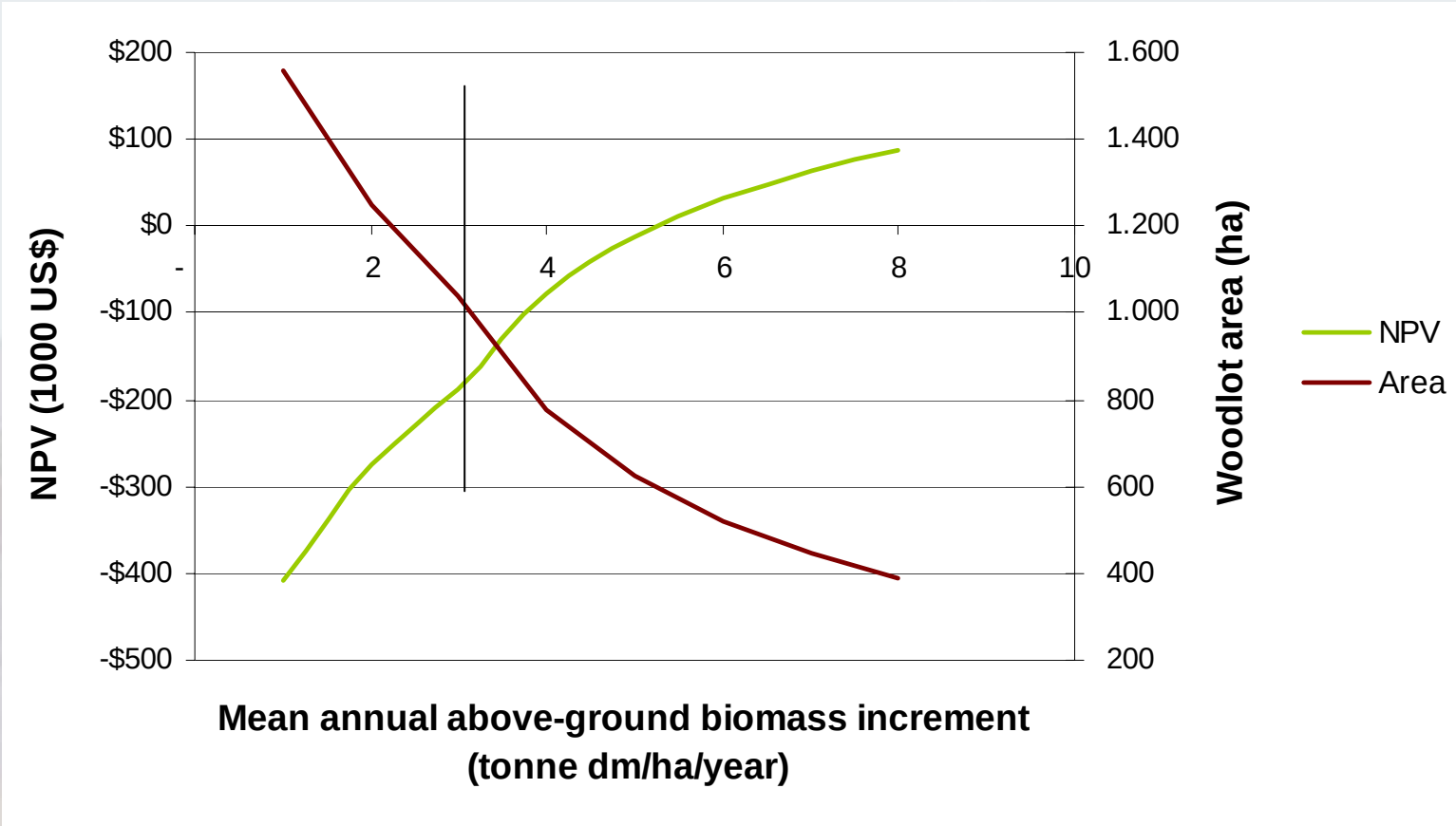
Costs of energy in baseline



NPV costs of carbon forestry

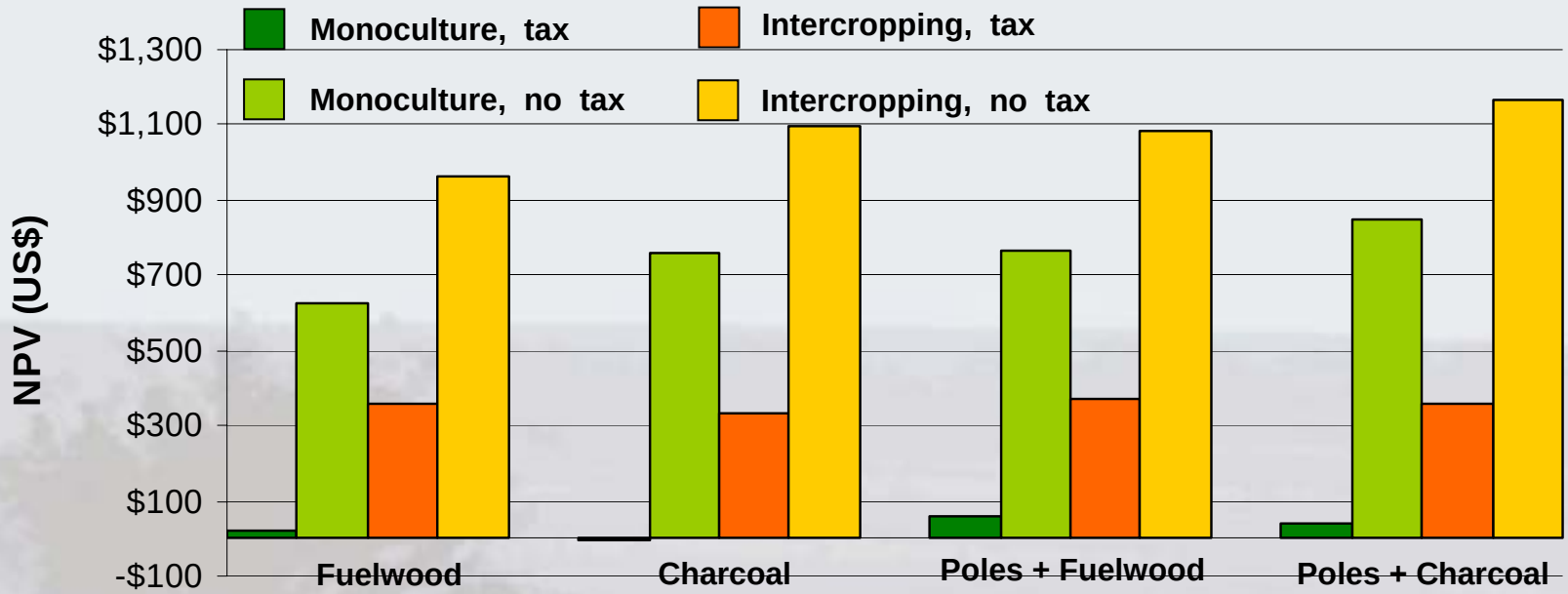


Carbon forestry and wood yields



- Small-scale CDM limitation not profitable at low yields

NPV per ha of rotational woodlots



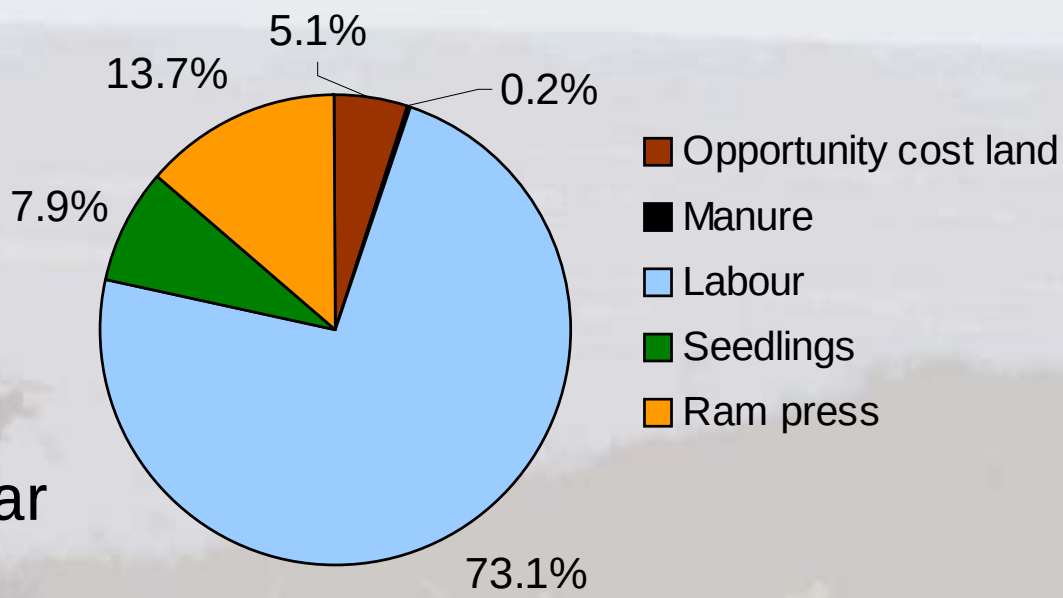
- NPV (RoL) increases with multiple products (poles, intercropping)
- NPV higher for charcoal production (labour intensive)
- RoL higher for fuelwood production
- Taxes on fuelwood plantation (per woodlot) high

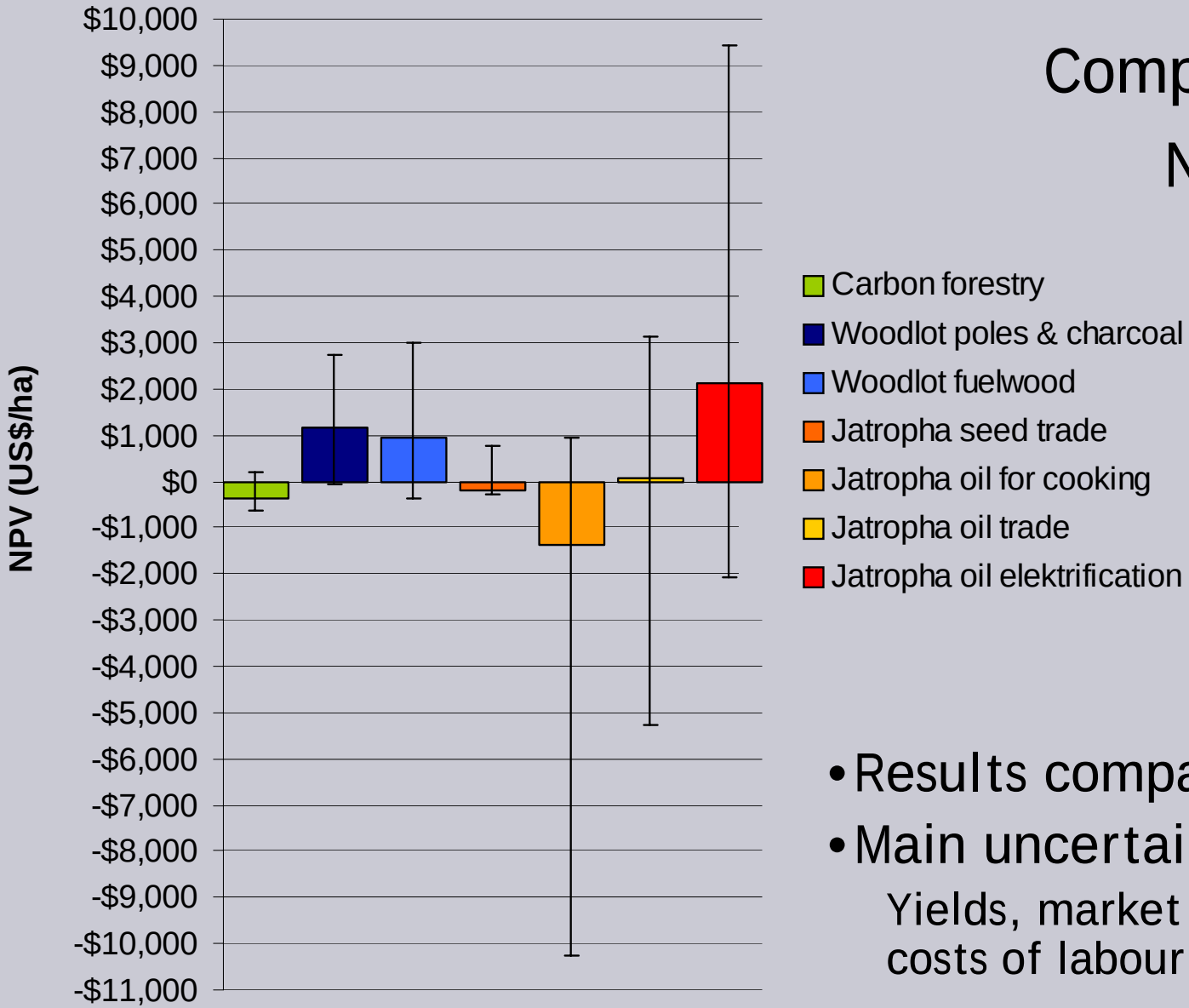
Jatropha production and use

- Intercropping and monoculture comparable production costs
  - difference in land used
- Trade of seeds
  - Price of seeds 100 Tsh/kg; NPV: -180 to - 230 US$/ha
- Trade of oil
  - Price of oil 0.75 US$/l; NPV: - 230 to – 1200 US$/ha
- Cooking on jatropha oil
  - Not competitive with other heat sources; NPV: - 1400 US$/ha
- Electricity production
  - Electricity production costs as difference to diesel 0.6 US$/kWh
  - NPV: 1600 -2100 US$/ha
- Soap production
  - NPV: 19300 - 23200 US$/ha

NPV costs of jatropha oil production

- Largest part of costs in labour
  - Harvest
  - Manual oil pressing
- Labour demand:
  - 299 man-days/ha/year





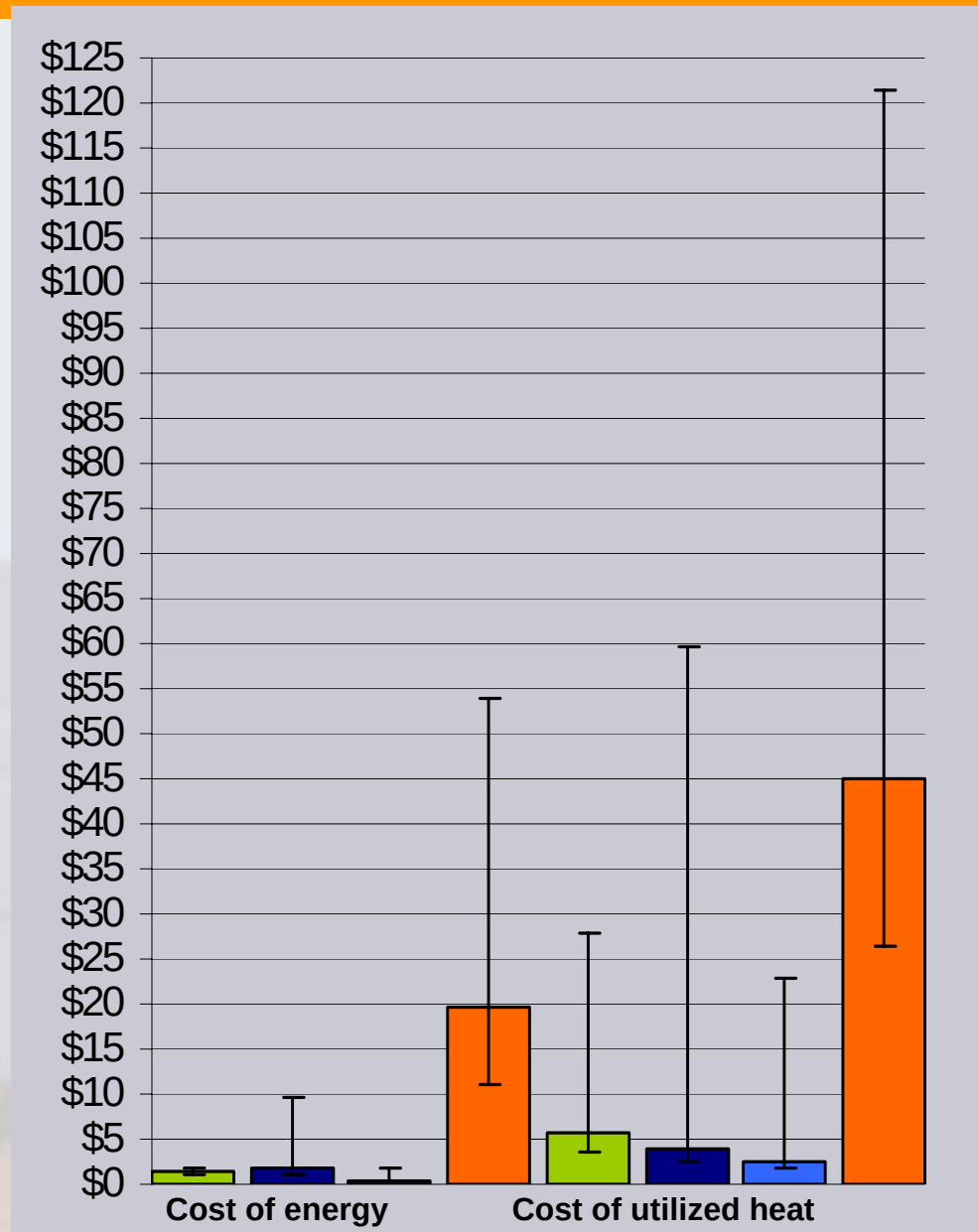
Comparison:

NPV

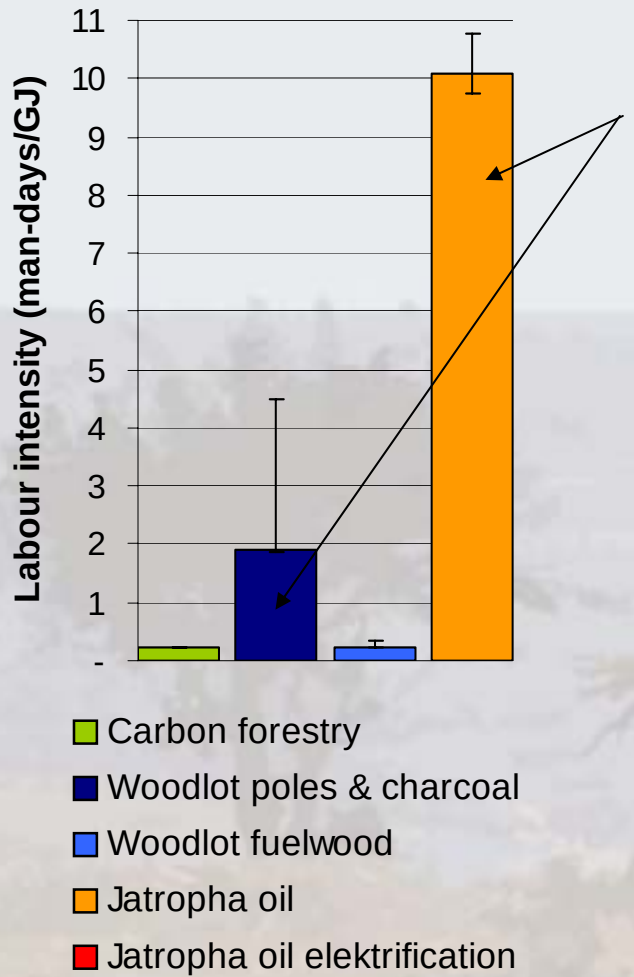
- Results comparable for RoL
- Main uncertainties:

  Yields, market prices, shadow costs of labour

Comparison: Costs of energy

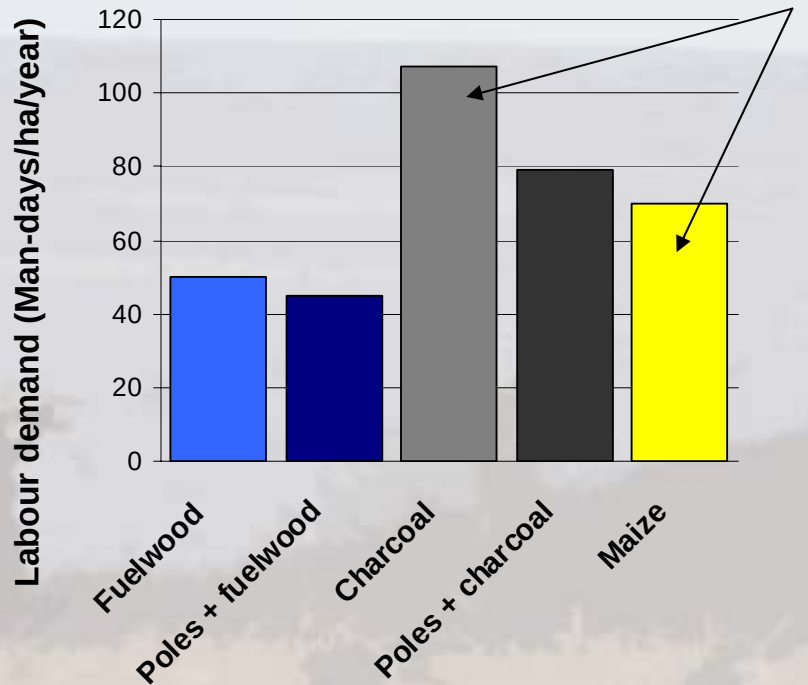


Comparison: labour intensity



Per GJ: labour intensity of jatropha oil and charcoal + poles high

Per ha, multi-product decreases labour intensity and intercropping comparable to maize



Conclusions

- Rotational woodlots preferable for household energy
  - Cost-effective measure against land degradation, energy poverty
- Jatropha oil as diesel substitute
  - Trade or electricity substitution
  - Contributes to rural electricifiation
- Trade-off between scarce land and scarce labour
  - In wet season, labour might be scarcer in Shinyanga
- Small-scale carbon forestry economically not feasible
  - But, large potential socio-economic, environmental benefits
  - Carbon forestry can finance forestation programmes partially

Report available: www.chem.uu.nl/nws