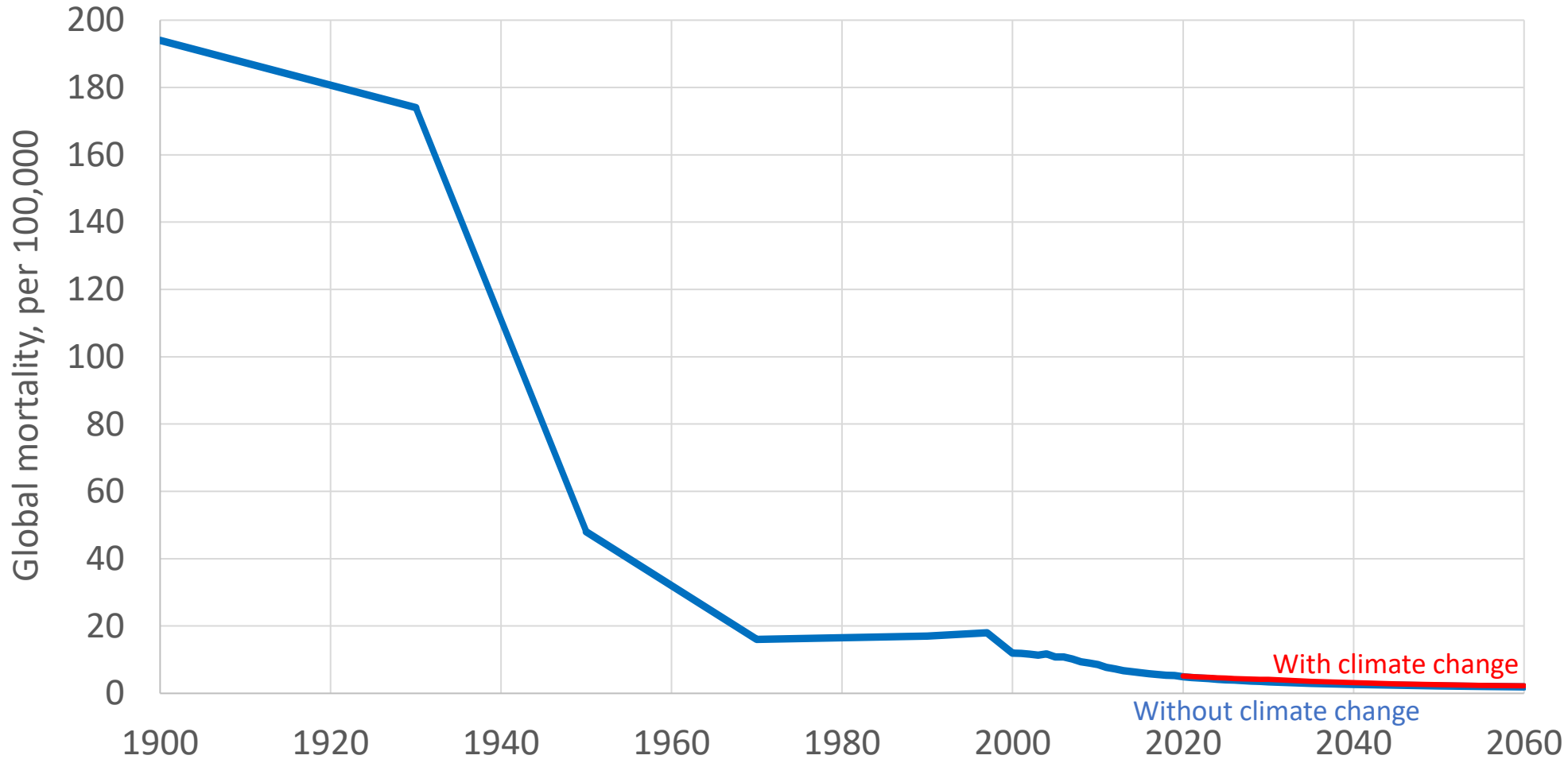
Climate change, natural resources and climate-proofing

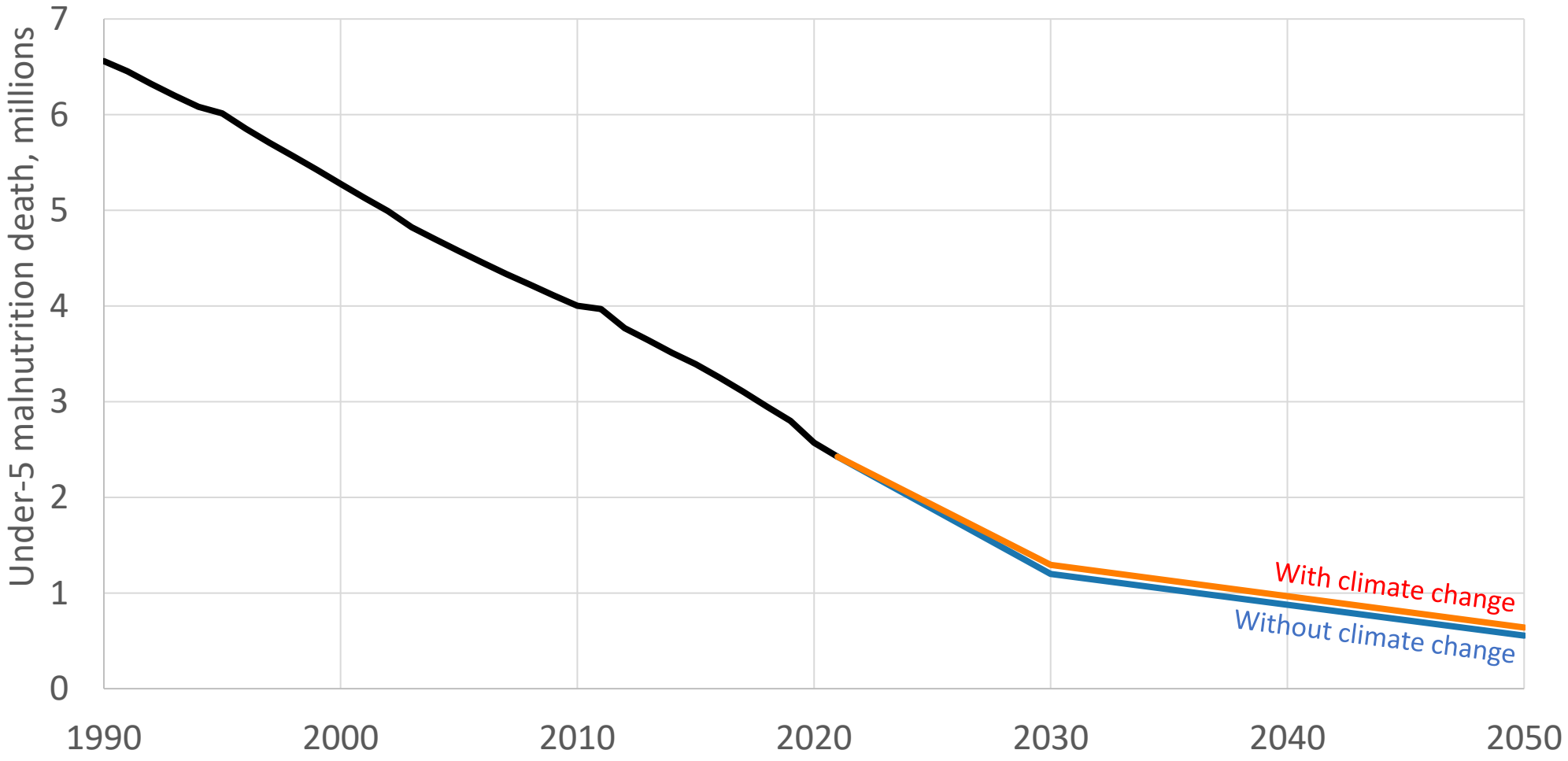
Climate change slows down improvments

Malaria, 1900-2060



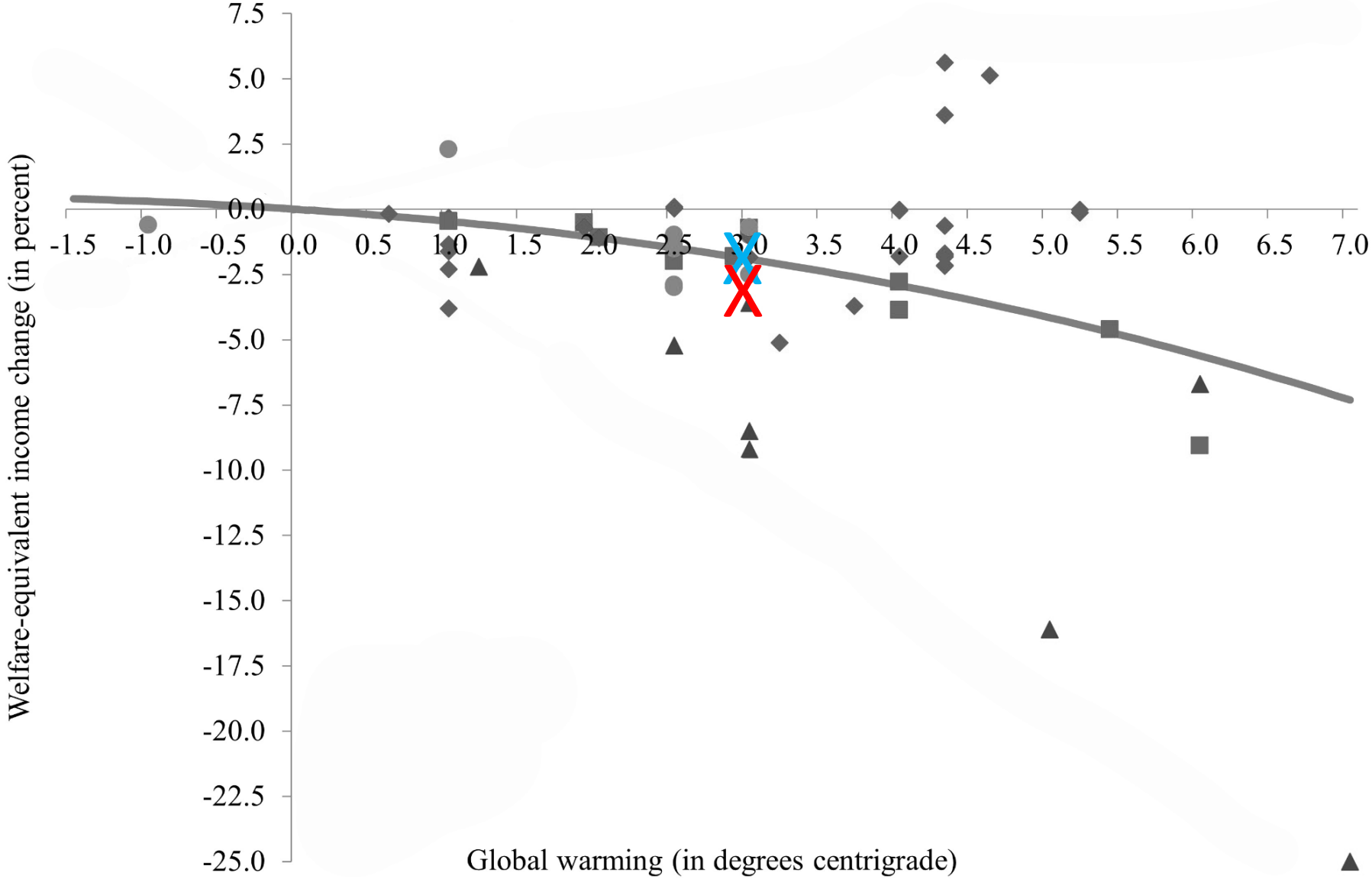
Carter & Mendis 2002, WHO 2014, World Malaria Report 2022

Hunger deaths, 1990-2050



GBD 2024, WHO 2014

Warming impact, in % income



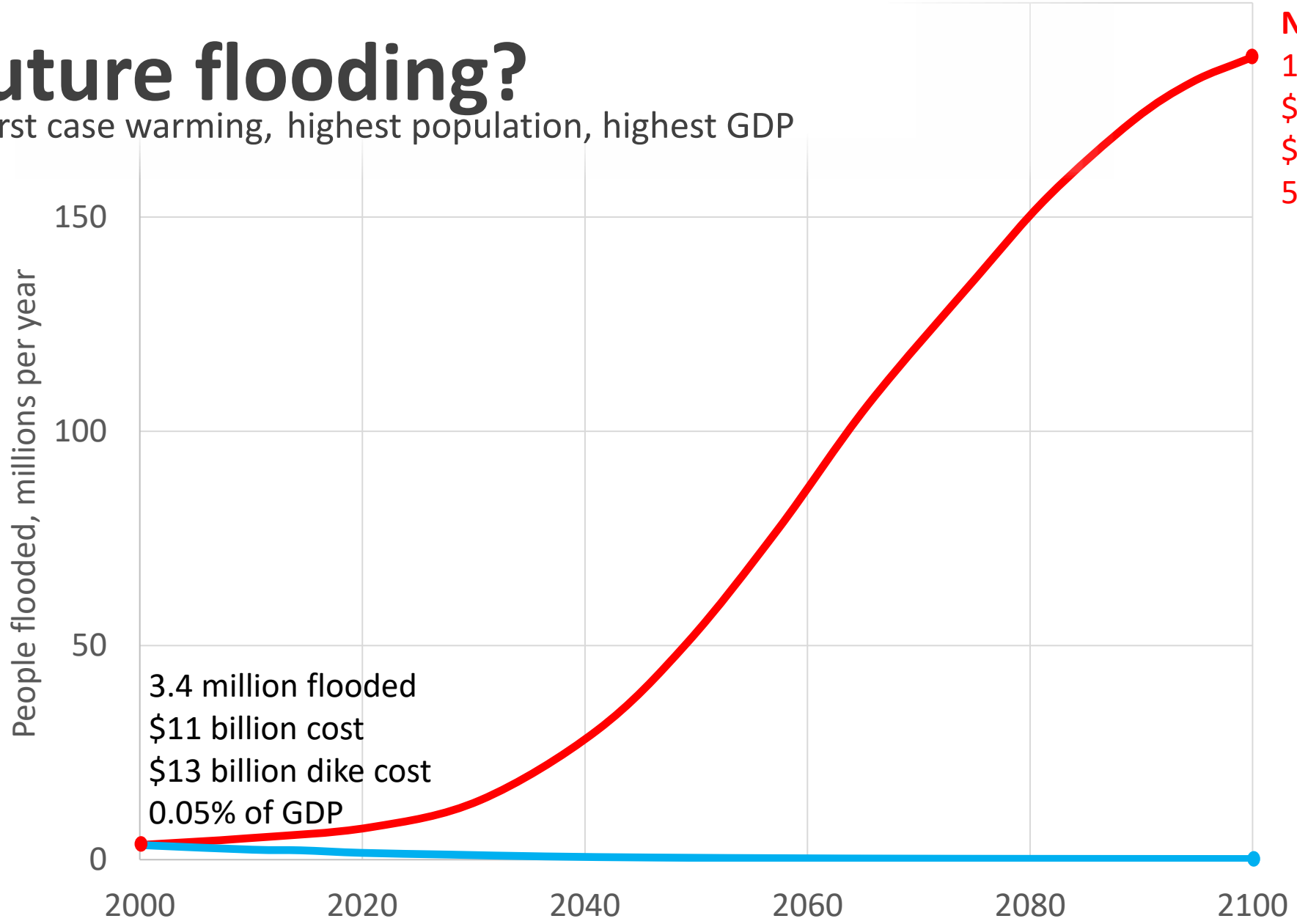
Tol 3°C: -1.9%
Nordhaus 3°C: -3.1%

Tol 2024, Nordhaus 2024

Adaptation matters

Future flooding?

Worst case warming, highest population, highest GDP



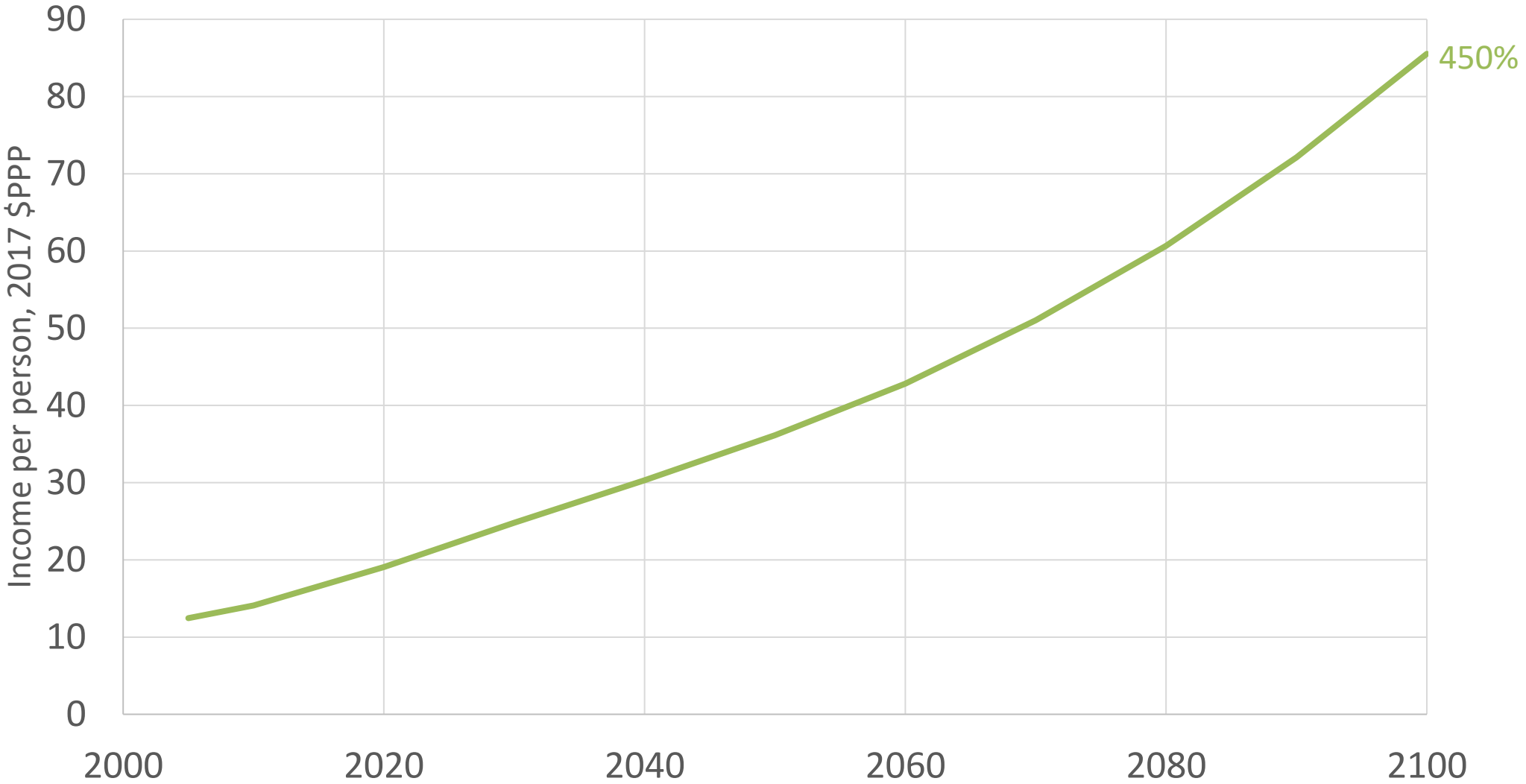
No adaptation
187 million flooded
$55 trillion flood cost
$24 billion dike cost
5.3% of GDP

Adaptation
15,000 flooded
$38 billion flood cost
$48 billion dike cost
0.008% of GDP

Hinkel et al, 2014

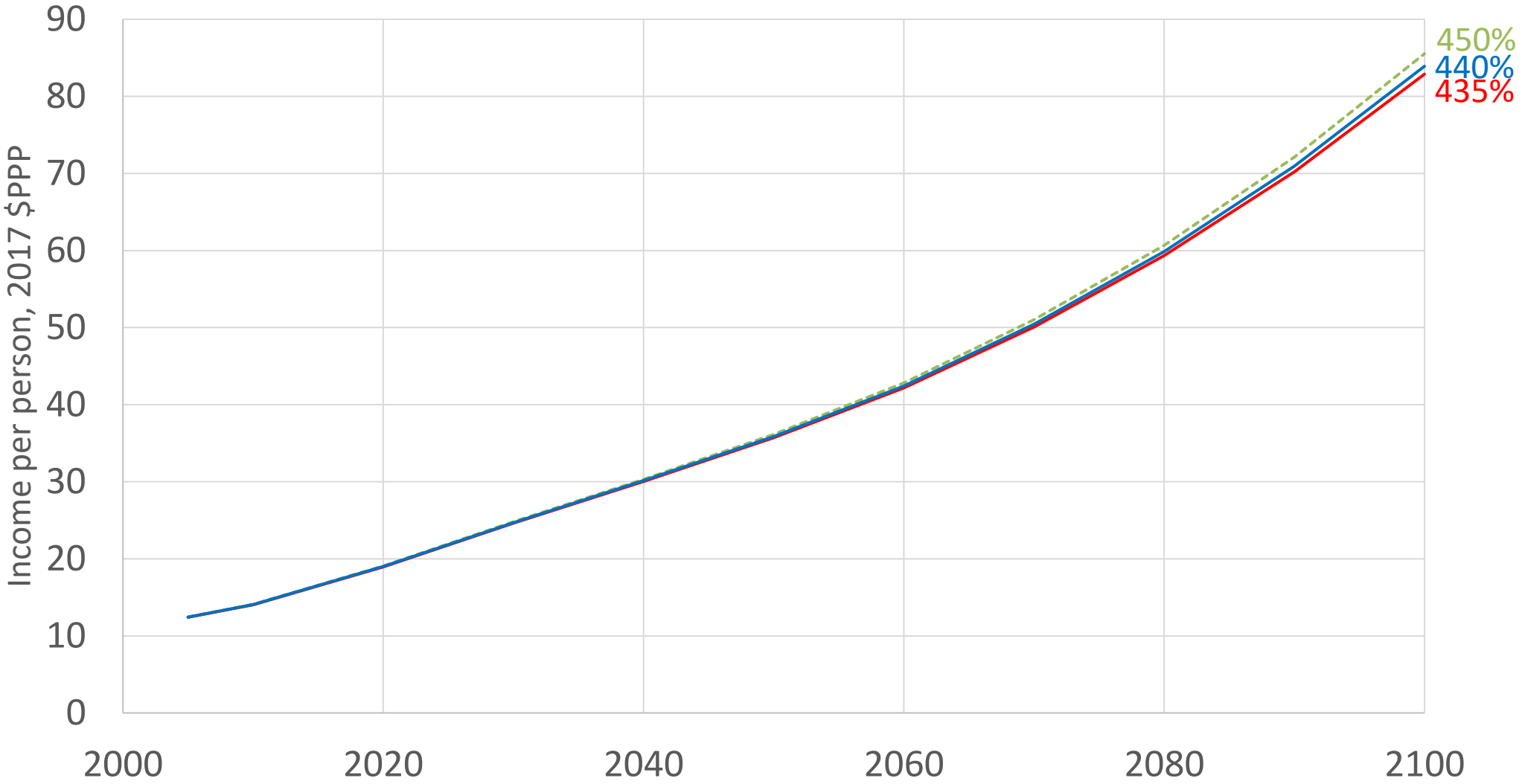
Forecasted income per peson in UN models

Average person 4.5x as rich



UN SSPs, Tol 2024, Nordhaus 2024

Because of climate, average person 4.4x as rich



UN SSPs, Tol 2024, Nordhaus 2024

Climate proofing development infrastructure investment (e.g., roads)

Policy area nominated by Eswatini

Climate-proofing a planned road

- Eswatini: 40 km road package
- Base-case cost-benefit analysis
- Real 2026 SZL | 20 years | 5% discount rate

What changes?

- Business as usual
  - **Road built to ordinary standards**
  - **Flood disruption: 10 days/year**
- Climate-proofing
  - **Better drainage and culverts**
  - **Slope and scour protection**
  - **Climate-informed maintenance**
  - **Flood disruption: 3 days/year**
- Result: 7 disruption days avoided annually

Incremental costs

- Capital premium
  - **40 km × SZL 420,000 = SZL 16.8m**
- Maintenance
  - **SZL 720,000/year**
  - **Present value: SZL 9.0m**
- Renewal
  - **SZL 3.2m every 5 years**
  - **Present value: SZL 7.2m**
- Total PV costs of climate-proofing: SZL 33.0m
  - **The ordinary road-construction cost is excluded**

Asset-protection benefits

- Avoided flood damage
  - **40 km x SZL 85,000/km repair cost x 70% avoided damage**
  - **SZL 2.38m annually**
  - **Present value: SZL 29.7m**
- Residual value:
  - **Value of the climate-proofing investment at the end of year 20**
  - **SZL 0.9m**
- Total PV Asset-protection benefits: SZL 30.6m

Road-user benefits

- 4,550 vehicle-trips protected in year 1
  - **650 vehicles/day x 7 days = 4,550**
- Time savings
  - **4,550 x 1.2 hours x SZL 85**
  - **First year: SZL 0.46m**
  - **Present value: SZL 6.8m**
- Avoided detour costs
  - **4,550 x 28 km x times SZL 7.50**
  - **First year: SZL 0.96m**
  - **Present value: SZL 14.0m**
- Total PV benefits: SZL 51.4m

Benefit cost ratio

- Total PV benefits: SZL 51.4m
- Total PV costs: SZL 33.0m
- BCR = 1.6 FAIR
- Avoided flood damage provides 58% of benefits

Climate Change & Natural Resource Management

Policy area nominated by Namibia


N-BiG

Policy Versus Business As Usual

- Business as usual
  - **Communal rangeland remain bush encroached**
  - **No incremental recovery in grazing capacity or groundwater recharge**
  - **Biomass market and certification access remains limited.**
- Policy scenario
  - **Treat 10,000 hectares using site-specific thinning prescriptions**
  - **Establish grazing plans, regrowth control and ecological monitoring**
  - **Support producer organization, certification and buyer access**
- Evidence used
  - **The Economics of Land Degradation Namibia national bush-control appraisal provides the benefit and cost structure used in the model**
  - **Note: Real 2015 Namibian dollars used to retain the source basis**

Benefits

	Present value
Groundwater recharge	N$19.6 million
Biomass products and energy	N$4.0 million
Grazing recovery	N$3.0 million
Carbon offsets	N$0.1 million
Total benefits	**N$26.6 million**

- Groundwater recharge:
  - **Increase from 1% to 2% of rainfall as bush control expands**
  - **Water used by additional cattle is deducted**
  - **Incremental cubic metres are valued using NamWater's implicit cost of water**

Benefits

	Present value
Groundwater recharge	N$19.6 million
Biomass products and energy	N$4.0 million
Grazing recovery	N$3.0 million
Carbon offsets	N$0.1 million
Total benefits	**N$26.6 million**

- Biomass products and energy
  - **Incremental charcoal volumes are valued at wholesale prices**
  - **Additional and substituted firewood at retail-price proxies**
  - **Biomass electricity at output multiplied by the prevailing electricity tariff**
  - **Residual twigs and leaves at a mulch price**

Benefits

	Present value
Groundwater recharge	N$19.6 million
Biomass products and energy	N$4.0 million
Grazing recovery	N$3.0 million
Carbon offsets	N$0.1 million
Total benefits	**N$26.6 million**

- Grazing recovery
  - **Reduced bush density is assumed to double cattle carrying capacity over four years**
  - **Additional cattle output is valued at the 2015 beef producer price relative to a BAU scenario with constant cattle numbers**
  - **The effect is based largely on farmer experience**

Benefits

	Present value
Groundwater recharge	N$19.6 million
Biomass products and energy	N$4.0 million
Grazing recovery	N$3.0 million
Carbon offsets	N$0.1 million
Total benefits	**N$26.6 million**

- Carbon offsets
  - **Avoided grid emissions from the biomass-electricity scenario are valued at N$60 per ton of CO_2 equivalent**
  - **The benefit depends on whether biomass electricity actually is produced and displaces more polluting generation**

Costs

	Present value
Bush thinning	N$17.0 million
Public enabling and setup	N$4.0 million
Livestock emissions	N$0.5 million
Soil-carbon loss	N$0.2 million
Total costs	**N$21.6 million**

- Bush thinning
  - **Combines five mechanical methods and manually applied arboricides, 90:10 treatment mix**
  - **Mechanical methods account for almost all cost**

Costs

	Present value
Bush thinning	N$17.0 million
Public enabling and setup	N$4.0 million
Livestock emissions	N$0.5 million
Soil-carbon loss	N$0.2 million
Total costs	**N$21.6 million**

- Public enabling and setup
  - **Not estimated in the ELD report**
  - **Estimate N$250 per treated hectare plus N$1.5 million for setup, covering certification, producer support, aftercare planning and monitoring**
  - **N$1 in 2015 ≈ N$1.5 in 2026**

Costs

	Present value
Bush thinning	N$17.0 million
Public enabling and setup	N$4.0 million
Livestock emissions	N$0.5 million
Soil-carbon loss	N$0.2 million
Total costs	**N$21.6 million**

- Livestock emissions
  - **Additional cattle live-weight is converted to emissions**
  - **11.93 kgCO_2e per additional kilogram of live-weight per year**
  - **Valued at the report's carbon-price N$60/ton**

Costs

	Present value
Bush thinning	N$17.0 million
Public enabling and setup	N$4.0 million
Livestock emissions	N$0.5 million
Additional livestock	N$0.5 million
Soil-carbon loss	N$0.2 million
Total costs	**N$22.1 million**

- Additional livestock
  - **Grazing recovery benefit is based on meat from incremental livestock**
  - **Livestock emissions implies around 190 additional animals**
  - **Sales value of 190 calves spread over 25 year**

Costs

	Present value
Bush thinning	N$17.0 million
Public enabling and setup	N$4.0 million
Livestock emissions	N$0.5 million
Additional livestock	N$0.5 million
Soil-carbon loss	N$0.2 million
Total costs	**N$22.1 million**

- Soil-carbon loss
  - **One-time reduction of 0.77 tons of CO_2 sequestered per treated hectare**
  - **Valued at N$60 per tCO_2e**

CBA result

- Present-value benefits: N$26.6 million
- Present-value costs: N$22.1 million
- Benefit-cost ratio: 1.2 FAIR