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BHUTAN ACADEMY

Agriculture: better livelihoods for every ngultrum

Methods, international evidence and Bhutan applications

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What will we learn in this block?

- Define the intervention and realistic business as usual
- List every cost and benefit for everyone affected
- Interpret poor, fair, good and excellent returns
- Reconstruct a published land-tenure CBA
- Apply the method to fencing and the Yarjugang proposal

Bhutan’s farming challenges

Agriculture supports many livelihoods

Measure, 2024	NSB result
Employment: agriculture, forestry and fishing	154,512 people · 41.7% of employment
GDP: agriculture, livestock and forestry	14.15% of GDP
What this suggests	Livelihoods depend on a sector with low average output per worker

Which investment can raise livelihoods at a justified cost?

Employment and GDP classifications differ slightly. These are sector shares, not programme effects.

Source: NSB: Labour Force Survey 2024 · additional references in notes

Food security and domestic production

- Households need reliable access to affordable, nutritious food
- Domestic production and imports can both contribute
  - **Self-sufficiency is one policy objective, not a benefit by itself**
- Support must create additional benefits beyond its full costs

Source: Bhutan Ministry of Finance: Budget 2024–25 · additional references in notes

What holds farmers back?

- Wildlife damage can reduce harvests and absorb guarding time
- Labour availability, terrain and scattered plots affect costs
- Public responses include irrigation, mechanisation and market links
- Crop protection requires continuing maintenance
  - **A large problem does not identify the best investment**

Source: Bhutan Ministry of Finance: Budget 2024–25 · additional references in notes

Could electric fencing improve farmers' livelihoods?

- Decision: one additional maintained fence for a farm group
- BAU: existing guarding and other protection continue
- Policy: installation, training, upkeep and replacement
- Potential gains: fewer crop losses and less guarding
  - **Who maintains it, and what happens to neighbouring farms?**

Source: Feuerbacher et al. (2021): Bhutan electric fencing

Agricultural benefits and costs

What changes compared with business as usual?

One-season teaching example	BAU	With intervention	Increment
Harvested output	1,000 kg	1,200 kg	+200 kg
Purchased inputs	Existing inputs	Existing + extra inputs	Count only the extra cost
Farmer labour	Existing work	Existing + extra work	Value the extra time

Additional benefit begins with the usable extra 200 kg

Invented physical example. No intervention effect or BCR is estimated.

Source: Robinson et al. (2019): benefit–cost reference guidelines

Additional output includes food eaten at home

Additional output	Teaching value	Gross benefit
120 kg sold	120 × Nu. 50/kg	Nu. 6,000
80 kg consumed at home	80 × Nu. 50/kg	Nu. 4,000
Total usable output	200 kg × Nu. 50/kg	Nu. 10,000

Home consumption has value. Gross output value is still before costs.

All quantities and prices are invented teaching inputs.

Source: Robinson et al. (2019): benefit–cost reference guidelines

The full costs extend beyond the public budget

- Setup: equipment, installation, training and administration
- Recurring costs: inputs, energy, upkeep and replacement
- Farmer costs: payments, extra labour and time away from other uses
- Other effects: pollution, land and water use, neighbours
  - **Review every stakeholder and every stage of the intervention**

Source: Robinson et al. (2019): benefit–cost reference guidelines · additional references in notes

Farmer income and societal benefits

Item	Treatment in the appraisal
Extra production and usable food	Value once, then include all extra resource costs
Cash grant or input reimbursement	Public cost and recipient gain, symmetrically
Equipment purchased for the programme	Count the resources once; avoid a duplicate asset benefit
Higher farmer selling price	Examine buyer effects and the wider market boundary

Private income gains and social gains need a consistent boundary

Source: Robinson et al. (2019): benefit–cost reference guidelines · additional references in notes

Which investments deliver the greatest benefits?

Poor, fair, good and excellent returns

Rating	Benefit–cost ratio	Interpretation
Poor	Below 1	Benefits smaller than costs
Fair	1 to below 5	Positive, relatively modest returns
Good	5 through 15	Substantial benefits relative to costs
Excellent	Above 15	Very high benefits relative to costs

BCR 1.7 is fair: Nu. 1.70 of benefits for each Nu. 1 of costs

Panel framework. Judge the evidence and calculate the ratio before assigning a rating.

Source: CCC Malawi: ratings and Eminent Panel provenance

Many agricultural programmes deliver modest returns

- Copenhagen Consensus review: 48 agricultural interventions
- Most reported BCRs fall between 0 and 5
  - **Published median ≈ 3, within the fair category**
- Many credit, insurance and local productivity cases return about 1–2
- Research and some institutional reforms can deliver much higher returns

Source: Rosegrant et al. (2023): agricultural R&D and CBA review · additional references in notes

Productivity, poverty reduction and social support

- Many programmes support vulnerable farmers as well as production
- Small additional harvests may be costly to generate
- Subsistence output has value even when households sell little
- Who benefits matters alongside the size of the BCR
  - **A fair return can coexist with a worthwhile poverty objective**

Source: CCC: Tonga review of agricultural policy options · additional references in notes

Different interventions, different returns

Specific intervention and geography	BCR	Rating
Revamp irrigation schemes · Ghana	1.5	Fair
Warehouses to reduce losses · Ghana	1.8	Fair
Tractor services · Ghana	2.8	Fair
Hybrid maize seed subsidy · Ghana	3.6	Fair
Commodity exchange reform · Malawi	16	Excellent
Rural land tenure · Sub-Saharan Africa	18	Excellent

Source-reported results at 8%. Different study designs and horizons; these are not Bhutan estimates.

Source: CCC: Ghana agriculture study · additional references in notes

Subsidies and debt relief: what changes for farmers?

- Debt relief can ease immediate financial distress
  - **It may miss farmers without formal borrowing**
- Input subsidies can induce additional seed or fertiliser use
- Count farmer inputs, labour, leakage and administration
- Separate redistribution from the resulting production gains

Source: CCC: Andhra Pradesh farmer distress study · additional references in notes

Better access to markets

Malawi COMEX reform	What the case teaches
Baseline	Two exchanges; duplicated and underused facilities
Additional investment	Grading, management and coordination reforms
Source-reported BCR at 8%	16 · Excellent
Bhutan appraisal question	What constraint would the local reform change?

A market platform needs a working market and a credible benefit pathway

Source: CCC: Malawi commodity exchange reform

Agricultural research: benefits spread over time

Study specification	Source-reported result
Increment	R&D funding above historical trends
Horizon and discount rate	35 years · 8%
PV costs / PV benefits	About US$61 billion / US$2.1 trillion
Benefit measure	Net producer + consumer surplus
Published BCR	33 · Excellent

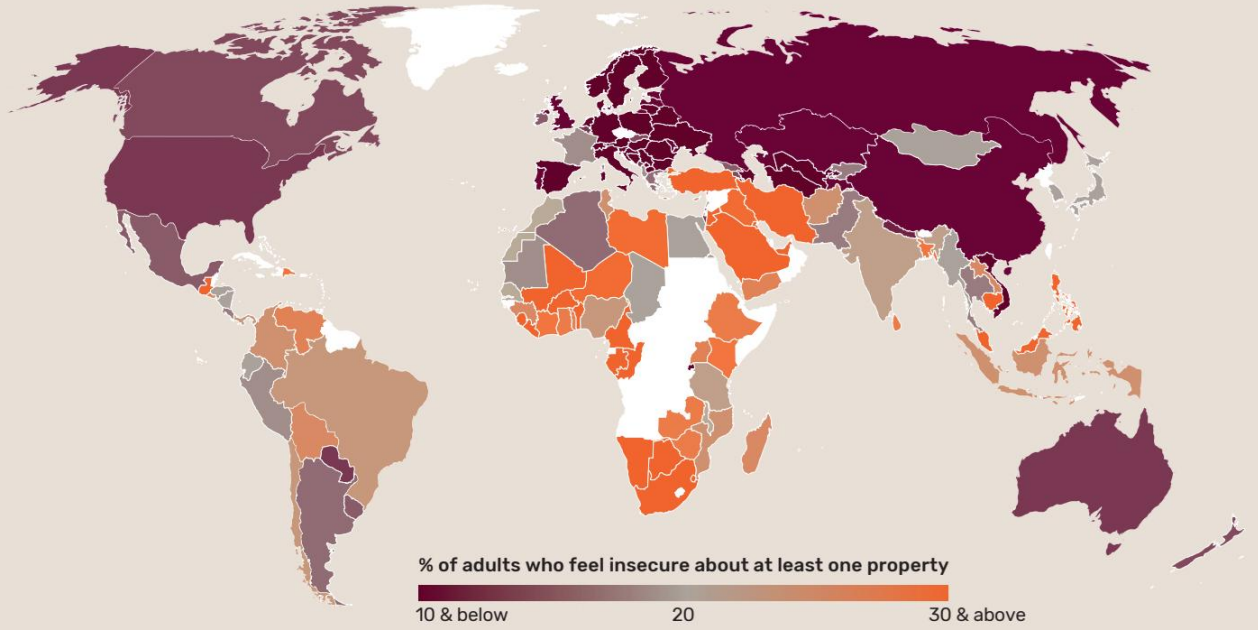
Published Global South scenario, not a Bhutan research estimate. Totals shown are rounded.

Source: CCC: agricultural R&D research · additional references in notes

Land tenure: a published agricultural CBA

How widespread is perceived land insecurity?

FIGURE 2: GLOBAL LEVELS OF PERCEIVED TENURE INSECURITY* BY COUNTRY



Source: Prindex (2020).

*Notes: *Perceived tenure insecurity as measured across all properties and plots of land that a respondent has rights to access or use, not just their 'main' property.*

Perceived insecurity across properties. Historical survey, not registration rates or a causal effect.

Source: Prindex (2020): global perceived tenure insecurity

How secure land rights could improve farm outcomes

- Intervention: recognised rights and effective land administration
- Potential pathway: greater confidence to invest and use land
- Registration needs dispute resolution and updated records
- Customary or communal rights can also provide security
  - **A document alone does not guarantee productive investment**

Source: Byamugisha and Dubosse (2023): land-tenure CBA

What does the evidence show?

Evidence / model element	Interpretation
Selected household-income effect	15% used in the rural CBA
Supporting income-effect cases	Nicaragua, Peru, India and Vietnam
African transfer	Effect may be more modest; transfer is uncertain
Benefit timing	No income benefit in the first five years

The selected effect is a modelling input, not a Bhutan estimate

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

From eligible parcels to programme coverage

Source baseline construction	Approximate result
96.6 million households × 2.2 parcels	212.6 million rural parcels
Unregistered parcels: 86% × 212.6 million	182.8 million parcels
Benefit model’s treated households	83 million households
Implementation	Registration expands over ten years

Source estimates use different survey-based denominators. Rounded counts are not an exact census.

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

Registration requires continuing administration

Cost component	How the original model treats it
Mapping and registration	Rural parcels and communal rights
Digitisation and institutions	Allocated system investments
Operations and records	Recurring service over the 30-year horizon
PV of all rural costs at 8%	US$21.72 billion

Discounted and undiscounted totals must not be mixed

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

From income gains to discounted benefits

Year 6 reconstruction	Calculation / result
Households receiving the benefit	83 million × 10% = 8.3 million
Income gain per household	US$4,075 × 15% = about US$611
Annual benefit	8.3 million × US$4,075 × 15% = US$5.073 bn
Present value at 8%	US$5.073 bn / 1.08^6 = US$3.197 bn

Full model: PV benefits US$395.71 bn over 30 years. Year example uses rounded source inputs.

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

Completing the land-tenure CBA

Published result · 8% discounting	US$ billion
Present value of benefits	395.71
Present value of costs	21.72
BCR = 395.71 / 21.72	18 · Excellent

Excellent in this model. Local design and evidence still determine transferability.

Source-reported model, 30-year horizon. This is not a Bhutan Academy estimate.

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

Electric fencing in Bhutan

Existing protection and the additional service

- Teaching decision unit: one additional scheme for 20 households
- BAU: guarding continues; 1,500 kg/year lost to wildlife
- Policy: maintained fence, training and replacement
  - **Ten years of service, 2027–2036; setup in 2026**
- Costs and benefits stay in real 2026 ngultrum

Source: Feuerbacher et al. (2021): Bhutan electric fencing

What would protection cost over its lifetime?

Teaching cost component	Timing	Real 2026 value
Fence purchase + public setup	Year 0	Nu. 300,000 + 40,000
Farmer installation: 400 h × Nu. 50	Year 0	Nu. 20,000
Materials/energy + upkeep: 200 h × Nu. 50	Each year 1–10	Nu. 20,000 + 10,000
Component replacement	Year 5	Nu. 60,000

Setup Nu. 360,000; recurring Nu. 30,000/year. All inputs are teaching assumptions.

Source: Feuerbacher et al. (2021): Bhutan electric fencing · additional references in notes

Crop losses and guarding time saved

Teaching benefit	Substitution	Annual value
Avoided crop loss	1,500 kg × 60% × Nu. 100/kg	Nu. 90,000
Guarding time saved	1,200 hours × Nu. 50/hour	Nu. 60,000
Total additional benefit	Nu. 90,000 + Nu. 60,000	Nu. 150,000

Food consumed at home and released guarding time both have value

Teaching assumptions throughout this example. Real 2026 ngultrum.

Source: Feuerbacher et al. (2021): Bhutan electric fencing

Discount the full cost of the fencing scheme

Discounted teaching cost	Result
Bhutan rate: 2 × 3.794%, rounded	8% · appendix derivation
Ten-year factor: $\Sigma\ 1 / 1.08^{t}$	6.710081
Setup + annual costs + replacement	$360{,}000 + 30{,}000 \times 6.710081 + 60{,}000 / 1.08^{5}$
Total present-value cost	Nu. 602,137

Use the same discounting for benefits, then compare the full BCR

All programme inputs assumed. Other uses of the resources remain relevant.

Source: World Bank: Bhutan real GNI per-capita growth · additional references in notes

Completing the fencing teaching appraisal

Full teaching appraisal, real 2026 Nu.	Present value at 8%
Benefits: 150,000 × 6.710081	Nu. 1,006,512
Full costs: setup + annual costs + replacement	Nu. 602,137
BCR: 1,006,512 / 602,137	1.7 · Fair
Net benefit: benefits − costs	Nu. 404,375

Positive net benefits on these assumptions, with maintenance and time savings

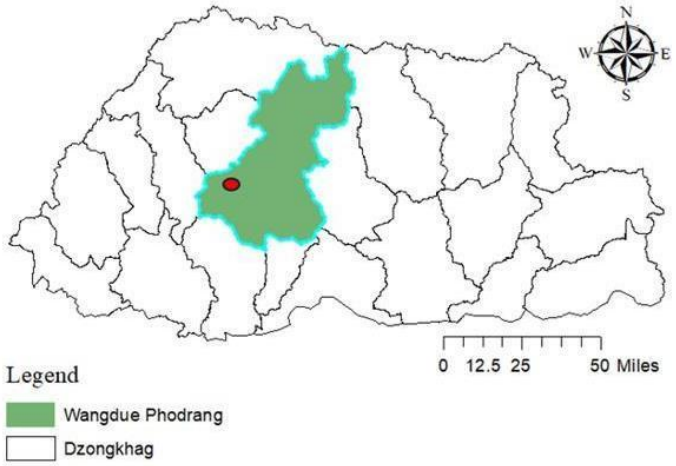
Illustrative proxy only. No BCR is claimed for an actual Bhutan fencing programme.

Source: Feuerbacher et al. (2021): Bhutan electric fencing · additional references in notes

Yarjugang: farming and prisoner reintegration

Yarjugang combines a farm and rehabilitation

- Farm production and prisoner reintegration
- 2024 proposal: 435 acres, around 305 cropped acres
- 200–300 agricultural workers
- Agriculture Nu. 184.8 million + PEMA Nu. 125.14 million
  - **Total proposed funding: Nu. 309.94 million**
- Accommodation, security and skills support



Location map from the 2024 proposal

Proposal budgets on their original price basis. Public PEMA page lists 432 acres: reconcile scope.

Source: The PEMA: Yarjugang reintegration and aftercare

What happens without Yarjugang?

- RBP continues buying food from existing suppliers
- Prisoners continue in prisons or other open-air programmes
  - **Some existing work projects will end, so relocation is needed**
- The land retains its current uses and environmental services
- Compare the farm package with credible housing and training alternatives

Source: The PEMA: Yarjugang reintegration and aftercare · additional references in notes

Food produced has value wherever it is used

- Value usable extra output after spoilage and wildlife losses
- Food eaten by prisoners can replace purchases at a comparable value
- Surplus needs buyers, transport, storage and a realistic selling price
  - **Count output or avoided food purchases once, not both**
- Check displaced production and effects on neighbouring suppliers

Source: Feuerbacher et al. (2021): Bhutan electric fencing · additional references in notes

Full costs include prisoners’ time and land

- Include farm capital, housing and training required by the chosen package
- Include seeds, energy, upkeep, replacement and supervision
- The proposal records zero labour payments
  - **Unpaid labour still uses time that has a counterfactual value**
- Review forest conversion, water use, erosion and biodiversity

Source: Robinson et al. (2019): benefit–cost reference guidelines · additional references in notes

Could rehabilitation add benefits beyond farming?

- Practical skills and support may improve employment after release
- Fewer offences could reduce victim losses and justice-system costs
- Less crowding and better living conditions may improve wellbeing
  - **Compare with the same prisoners' existing work and training**
- These additional effects remain unquantified for Yarjugang

Source: The PEMA: Yarjugang reintegration and aftercare · additional references in notes

Yarjugang: the proposal becomes a proxy model

Model element	Source or explicit proxy
Capital	163.04 + 125.14 = Nu.288.18 million
Construction timing	Half in 2025, half in 2026: assumed
Output timing	Proposal years 3–10: 2027–2034
Price and rate	Approximate real 2024 Nu.; 8%
After release	Three-year benefit tail, ending in 2037

Ex-ante 2024 package. Price basis, timing and BAU remain proxies.

Source: The PEMA: Yarjugang reintegration and aftercare · additional references in notes

The forecast output must cover recurring costs

Year offset	Gross output, Nu.m	Production inputs, Nu.m
1–2	0.00	0.00
3	36.40	12.32
4	47.76	21.76
10	59.99	21.81

Year 10 inputs: 26.04 / 1.03^{6} ≈ 21.81 million

Administration, replacement, labour and added support are further costs. Output counted once.

Source: The PEMA: Yarjugang reintegration and aftercare · additional references in notes

Unpaid labour and support still use resources

Additional resource	Assumed arithmetic	Annual Nu.m
Prisoner time	250 × 220 days × 4 h × Nu.50	11.0
Supervision/security above BAU	Net additional resources	2.0
Training/aftercare above BAU	Net additional resources	1.0

- All three costs apply in years 3–10
  - **Forest, water and soil harms remain unpriced**

Shadow time value and additional costs are teaching proxies in real 2024 Nu.

Source: Robinson et al. (2019): benefit–cost reference guidelines · additional references in notes

Rehabilitation: a deliberately small proxy benefit

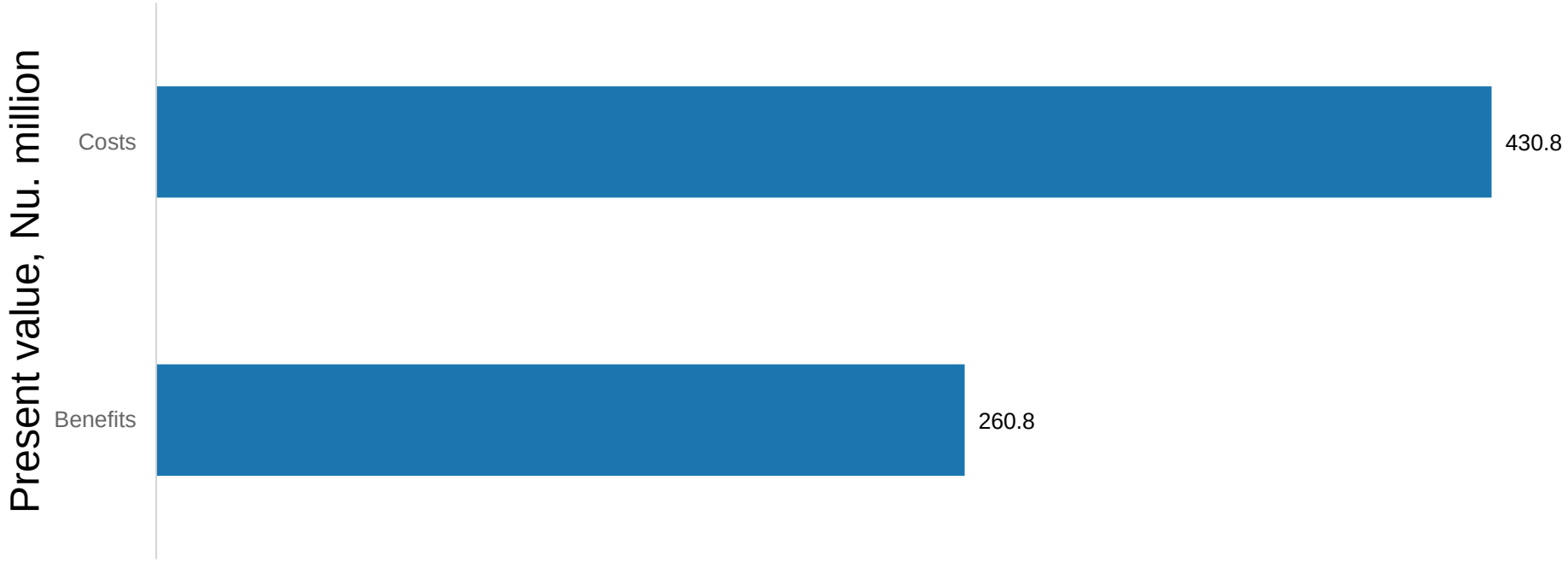
Per annual release cohort	Assumed calculation	Benefit
Extra employment	50 × 5% × Nu.100,000	Nu.250,000/year × 3
Fewer reoffending cases	50 × 2% × Nu.300,000	Nu.300,000 in year +3

- 50 releases per year during years 3–10 is assumed
  - **Benefits after release continue through year 13**

Illustrative expectations. International education evidence only supports considering these pathways.

Source: The PEMA: Yarjugang reintegration and aftercare · additional references in notes

Discounted costs exceed the proxy benefits



PV = Σ $amount_t$ / 1.08^t, measured at 2024

Includes assumed rehabilitation. Environmental harms and wellbeing gains remain unpriced.

Source: World Bank: Bhutan real GNI per-capita growth · additional references in notes

The quantified proxy BCR is poor

Quantified base proxy	Result
PV benefits	Nu. 260,801,696
PV costs	Nu. 430,831,901
BCR = 260.8 / 430.8	0.6 · Poor
Net benefit: benefits − costs	-Nu. 170,030,204

This proxy does not support the full package on monetised efficiency grounds

Proxy result. Unpriced environmental harms and wellbeing gains remain outside the ratio.

Source: CCC Malawi: ratings and Eminent Panel provenance · additional references in notes

Would this be a priority use of resources?

- The base proxy BCR is 0.6: poor
- Compare feasible alternatives using the same social perspective
  - **Other interventions may return 2, 5 or 50 per ngultrum**
- Test uncertain assumptions before ranking the proposal
- Keep rehabilitation and distributional objectives visible

Source: Robinson et al. (2019): benefit–cost reference guidelines · additional references in notes

Appendix: evidence, calculations and further reading

Ghana: agricultural investment results

Ghana programme	BCR at 8%	Rating
Fertiliser subsidy extension	4.4	Fair
Hybrid maize seed subsidy	3.6	Fair
Tractor mechanisation services	2.8	Fair
OPV maize seed subsidy	2.3	Fair
Warehouses to reduce post-harvest losses	1.8	Fair
Revamped irrigation schemes	1.5	Fair

Programme-specific source models. Cost boundaries and evidence differ from a new Bhutan appraisal.

Source: CCC: Ghana agriculture study · additional references in notes

Malawi: selected published results

Malawi programme	Published BCR	Rating
Land titling reform	73	Excellent
Commodity exchange reform	16	Excellent
Gravity irrigation: cassava case	3.3	Fair
Climate-smart agriculture	3.0	Fair
PICS storage bags	2.9	Fair
Solar irrigation, most estate crop cases	Mostly below 1	Poor

Selected source-reported results. Original case briefs and technical reports define the scope.

Source: CCC: Malawi policy briefs · additional references in notes

Rural land registration: component reconstruction

Registration component	Units × unit cost	US$ billion
Average-value individual parcels	164.6 million × US$10	1.646
High-value individual parcels	18.3 million × US$20	0.366
Formalised communal groups	15 countries × US$30 million	0.450
Other communal groups	15 countries × US$40 million	0.600
Registration subtotal	Sum of these four components	3.062

Registration only, undiscounted. Full rural model PV cost: US$21.72 billion at 8%.

Source: Byamugisha and Dubosse: full research manuscript · additional references in notes

Urban registration: an optional extension

Housing-price input	PV benefits, US$ bn	PV costs, US$ bn	BCR
Simple average	236.93	5.29	45
Population weighted	159.89	5.29	30

- Property values capitalise future services and security
  - **Do not add the same rental or housing-service gain again**

Both cases use the source's 8% discounting and original geographic assumptions.

Source: Byamugisha and Dubosse (2023): land-tenure CBA · additional references in notes

Sensitivity: what changes the fencing result?

Teaching scenario	Crop loss reduced	Hours saved/year	BCR	Rating
Base teaching case	60%	1200	1.7	Fair
Less effective fence	30%	1200	1.2	Fair
Lower guarding-time saving	60%	600	1.3	Fair
Both benefits lower	30%	600	0.84	Poor

Time savings and maintained protection can change the decision

Costs held constant to isolate benefit drivers. All programme inputs remain assumptions.

Source: Feuerbacher et al. (2021): Bhutan electric fencing · additional references in notes

Evidence needed for a real Bhutan appraisal

- Losses, crops, prices and guarding time under credible BAU
- Fence effectiveness, durability and residual guarding
- Local procurement, training, energy, upkeep and replacement costs
- Farmer labour values and effects on neighbouring farms
- Coverage, management responsibilities and the next expansion

Source: Feuerbacher et al. (2021): Bhutan electric fencing · additional references in notes

Public references: Bhutan and methodology

NSB: Labour Force Survey 2024

NSB: National Accounts Statistics 2025, 2024 data

Bhutan Ministry of Finance: Budget 2024–25

Feuerbacher et al. (2021): Bhutan electric fencing

World Bank: Bhutan real GNI per-capita growth

Robinson et al. (2019): benefit–cost reference guidelines

Public references: international evidence

CCC Malawi: ratings and Eminent Panel provenance

CCC: Ghana agriculture study

CCC: Malawi policy briefs

Byamugisha and Dubosse (2023): land-tenure CBA

Rosegrant et al. (2023): agricultural R&D and CBA review

CCC: Andhra Pradesh farmer distress study