THE GLOBAL PARTNERSHIP ON FOREST LANDSCAPE RESTORATION

BONN CHALLENGE 2011

Assessing economic impacts of restoration and building a carbon abatement curve

WORLD RESOURCES INSTITUTE

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What does economics have to do with restoration?

- Globally, there are more than 2 billion hectares of degraded land.
- With this tremendous opportunity, deciding where, when, and how landscapes should be restored is important.
- The answers to these questions must be formed on the basis of restoration's expected impacts on ecosystem goods and services.

How can economics help?

- An ROI framework is appropriate for serving the decision making processes at the country, regional, or local level.
- Framework assesses the ecosystem service and economic impacts of forest landscape restoration to help decision makers understand trade-offs.
- Carbon abatement curves show how much carbon each transition could capture and helps decision makers offset emissions by restoring landscapes as efficiently as possible.

Four steps in applying the ROI framework

1. *Identify degraded forest landscapes and their land uses:* Map landscapes in need of restoration as well as the characteristics of the landscapes.

2. *Identify restoration transitions:* Determine which restoration interventions could be used to restore each type of degraded land use.

3. *Model and value the change in ecosystem goods and service production for each restoration transition*: Calculate the net change in ecosystem goods and service production.

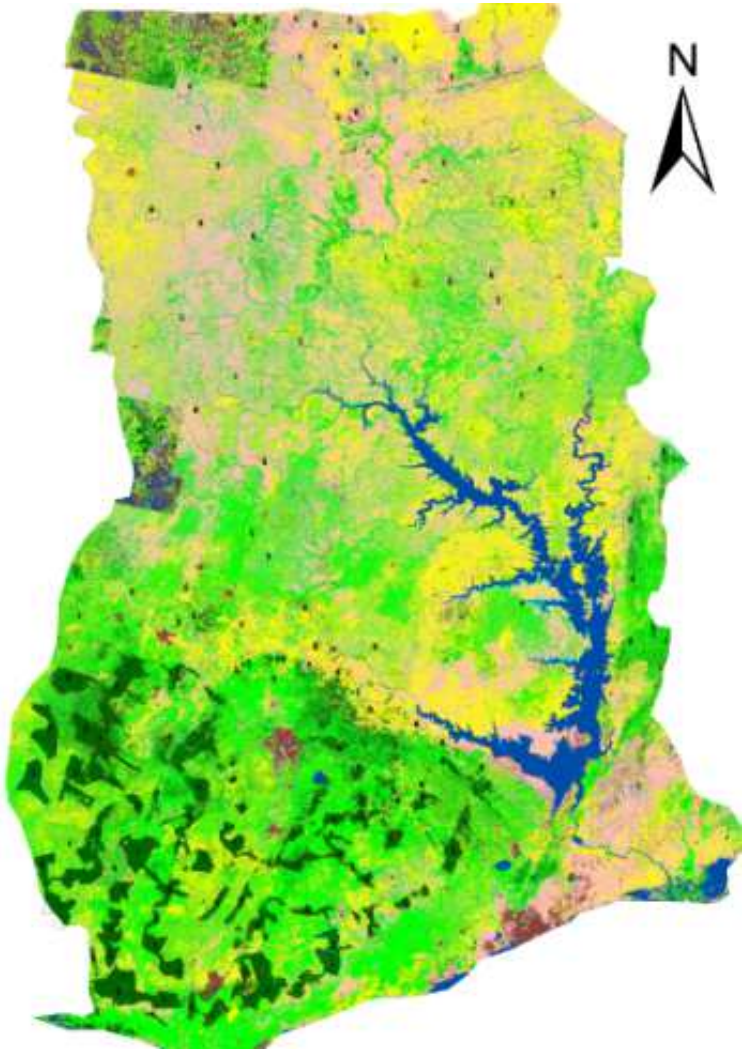
4. *Conduct sensitivity and uncertainty analysis:* See how sensitive the cost-benefit results are to changes in key variables like prices, interest rates, and biological assumptions.

Analysis Process

Step 1: Identify degraded forest landscapes and their land uses

- Map landscapes in need of restoration, as well as the characteristics of the landscapes.
- Degraded landscapes should be characterized in terms of current land uses and land cover, weather, socio-economic conditions, and other contextual information.

Geospatial analysis



- Geospatial analysis used to quantify areas of degraded land use that are also opportunity areas for forest and landscape restoration.
- Analysis based on geospatial datasets including elevation, slope, land cover, forest cover, water bodies, parks and reserves, and administrative areas.
- Five degraded categories: deforested land, agriculture, native forest, plantations, and farm fallow

Step 2: Identify restoration transitions

- Determine which restoration interventions could be used to restore each type of degraded land use.
  - For example, degraded agricultural land could be restored to agroforestry and
  - deforested land could be restored to secondary forests through natural regeneration.

Example of restoration transitions

Conventional agriculture →

Agroforestry

Poorly managed woodlots →

Well managed woodlots

Deforested land →

Naturally regenerated forests

Define restoration transition actions

- **Make relatively reliable estimates of the different technical specifications involved in each transition**

- **A Multistakeholder approach**

- Examples from Rwanda
  - **Conventional agriculture → Agroforestry**
    - Sale of crops is only source of revenue for agriculture
    - Agroforestry would add 300 additional trees/ha to agricultural land
    - Leaves from trees would be used as green manure, reducing fertilizer costs
    - Rotation interval for trees is 20 years
  - **Poorly managed woodlots → Well managed woodlots**
    - Poorly managed woodlots stock 1,100 trees per hectare
    - Well managed woodlots stock 1,600 trees per hectare
    - After 1 year, 15% of seedlings are replanted
    - After 4^{th} year 250 trees/ha are removed for thinning

Step 2: Restoration transitions

1. Deforested land to tree planting
2. Degraded natural forest to naturally regenerated forest
3. Degraded forest plantation to improved plantation management
4. Degraded agriculture to agroforestry
5. Poor farm fallow to improved farm fallow

Step 3: Value change in ecosystem services

- The quantity of ecosystem services and their value can be estimated using a number of methods depending on how available biological and market data are.

- In data rich situations more accurate and advanced methods can be used, such as biological production functions.

- In data poor situations benefit-transfer techniques can be used to construct look-up tables of land-use values.

- Here we use a look-up table approach using stylized data.

Step 3: Value change in ecosystem services

- Our goal: estimate economic returns of each restoration transition and identify areas where restoration would have a large, positive impact.

- To do this: compare the value of ecosystem services gained through restoration with the costs of restoration.

- Columns [1a-1c; 2a-2c] in the look-up table are the physical units of ecosystem goods and service that can be measure in the field.

- Columns [1d-1h; 2d-2h] are the values of the ecosystem goods and services, which may be estimated from the information in [1a-1c; 2a-2c] or filled in from estimates in the peer-reviewed literature.

- Column [1i; 2i] is cost of operating each land use.

Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

Restoration Opportunity Assessment Look-up Table										
	Ecosystem goods and services			Monetized benefit estimates						
Land uses	Timber (M3/ha)	Carbon (tons/ha)	Crop Production (tonnes)	Timber revenue	Carbon revenue	Crop revenue	Value of erosion prevention	NTFPs value	Cost/ha	NPV
Degraded land uses	[1a]	[1b]	[1c]	[1d]	[1e]	[1f]	[1g]	[1h]	[1i]	
1. Deforested land	0	0	0	$0	$0	$0	$0	$0	$50	-$50
2. Degraded natural forest	200	100	0	$0	$2,569	$0	$1,000	$1,000	$100	$4,469
3. Degraded forest plantation	180	90	0	$2,700	$2,312	$0	$750	$500	$4,000	$2,262
4. Degraded agriculture	0	0	18	$0	$0	$3,600	$500	$300	$5,000	-$600
5.Poor farm fallow	0	0	10	$0	$0	$2,000	$250	$200	$2,200	$250
Restoration interventions	[2a]	[2b]	[2c]	[2d]	[2e]	[2f]	[2g]	[2h]	[2i]	
1.Tree planting	300	150	0	$4,500	$3,854	$0	$1,500	$500	$7,000	$3,354
2. Natural regeneration to establish blocks of forest	400	200	0	$0	$5,138	$0	$2,000	$1,000	$1,000	$7,138
3. Improved plantation management	300	150	0	$4,500	$3,854	$0	$1,500	$500	$7,000	$3,354
4. Agroforestry	160	80	24	$2,400	$2,055	$4,800	$1,000	$300	$7,500	$3,055
5. Improved fallow	40	20	16	$600	$514	$3,200	$500	$200	$4,500	$514

Biophysical values/landscape characteristics

Economic values based on biophysical values

Costs

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

1. What is the value of restoring deforested land with silviculture?

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1. Timber revenue: $4,500

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

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1. Timber revenue: $4,500
2. Carbon revenue: $3,854

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

1. What is the value of restoring deforested land with silviculture?

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1. Timber revenue: $4,500
2. Carbon revenue: $3,854
3. Reduced erosion: $1,500

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

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1. Timber revenue: $4,500
2. Carbon revenue: $3,854
3. Reduced erosion: $1,500
4. NTFPs: $500

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

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1. Timber revenue: $4,500
2. Carbon revenue: $3,854
3. Reduced erosion: $1,500
4. NTFPs: $500
5. Costs: $6,950

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Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

1. What is the value of restoring deforested land with silviculture?

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1. Timber revenue: $4,500
2. Carbon revenue: $3,854
3. Reduced erosion: $1,500
4. NTFPs: $500
5. Costs: $6,950
6. NPV: $3,404

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Step 3: Value change in ecosystem services

- The net present value (NPV) concept allows various sums of money to be compared over time.
- For example, $10 received a year from now would have a NPV of $9 assuming the future is discounted at a rate of 10%.
- NPV greater than zero suggests that restoring degraded landscape is a worthwhile.
- NPV less than zero suggests that restoring the degraded landscape will generate too few benefits to justify the costs.

Step 3: Value change in ecosystem services

- ROI calculates the amount of value (measured in currency) that would be generated by every dollar invested in the restoration transition.

- For example, an ROI of 0.2 means for each dollar invested $1.20 worth of ecosystem goods and services would be created.

- Private investors and private landowners want to achieve large ROIs through land use transitions

Step 3: Value change in ecosystem services – calculate ROI with the Look-up Table and ROI Worksheet

- We repeat this exercise for every restoration transition
- This tells us the Cost, NPV and ROI of each transition

Restoration Opportunity Assessment ROI Table											
	Ecosystem goods and services			Monetized benefit estimates							
	Timber (M3/ha)	Carbon (tons/ha)	Crop Production (tonnes)	Timber revenue	Carbon revenue	Crop revenue	Value of erosion prevention	NTFPs value	Cost/ha	NPV	ROI
Restoration transition	[2a-1a]	[2b-1b]	[2c-1c]	[2d-1d]	[2e-1e]	[2f-1f]	[2g-1g]	[2h-1h]	[2i-1i]	(Rev -cost)	[(Rev - cost)/cost]
1. Deforested land to tree planting	300	150	0	4,500	3,854	0	1,500	500	6,950	$3,404	0.49
2. Degraded natural forest to Naturally regenerated forests	200	100	0	0	2,569	0	1,000	0	900	$2,669	2.97
3. Degraded forest plantation to Silviculture	120	60	0	1,800	1,541	0	750	0	3,000	$1,091	0.36
4. Degraded agriculture to Agroforestry	160	80	6	2,400	2,055	1,200	500	0	2,500	$3,655	1.46
5.Poor farm fallow to Improved farm fallow	40	20	6	600	514	1,200	250	0	2,300	$264	0.11

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Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
- How much revenue would be expected?
- For every dollar invested in the restoration of this landscape how many additional dollars of benefits are created?

Restoration Opportunity Assessment ROI Table											
	Ecosystem goods and services			Monetized benefit estimates							
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5.Poor farm fallow to Improved farm fallow	40	20	6	600	514	1,200	250	0	2,300	$264	0.11

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	[1]	[2]	[3]	[1*3]	[2*3]	
1. Deforested land to tree planting	6,950	3,404	4,000	$27,800,000	$13,614,000	1.09
2. Degraded natural forest to Naturally regenerated forests	900	2,669	2,000	$1,800,000	$5,338,000	
3. Degraded forest plantation to Silviculture	3,000	1,091	10,000	$30,000,000	$10,914,000	
4. Degraded agriculture to Agroforestry	2,500	3,655	40,000	$100,000,000	$146,208,000	
5.Poor farm fallow to Improved farm fallow	2,300	264	1,000	$2,300,000	$263,800	

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Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	**[1]**	**[2]**	**[3]**	**[1*3]**	**[2*3]**	
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5.Poor farm fallow to Improved farm fallow	2,300	264	1,000	$2,300,000	$263,800	

Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
  - $162 million would be need to restore the landscape. This represents both material and labor costs

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
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1. Deforested land to tree planting	6,950	3,404	4,000	$27,800,000	$13,614,000	1.09
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3. Degraded forest plantation to Silviculture	3,000	1,091	10,000	$30,000,000	$10,914,000	
4. Degraded agriculture to Agroforestry	2,500	3,655	40,000	$100,000,000	$146,208,000	
5.Poor farm fallow to Improved farm fallow	2,300	264	1,000	$2,300,000	$263,800	

Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
  - $162 million would be need to restore the landscape. This represents both material and labor costs

- How much revenue would be expected?

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	**[1]**	**[2]**	**[3]**	**[1*3]**	**[2*3]**	
1. Deforested land to tree planting	6,950	3,404	4,000	$27,800,000	$13,614,000	1.09
2. Degraded natural forest to Naturally regenerated forests	900	2,669	2,000	$1,800,000	$5,338,000	
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Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
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- How much revenue would be expected?
  - Restoring the landscape would generate $176 million over the restoration horizon (20 – 30 years)

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	**[1]**	**[2]**	**[3]**	**[1*3]**	**[2*3]**	
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Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
  - $162 million would be need to restore the landscape. This represents both material and labor costs
- How much revenue would be expected?
  - Restoring the landscape would generate $176 million over the restoration horizon (20 – 30 years)
- For every dollar invested in the restoration of this landscape how many additional dollars of benefits are created?

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	**[1]**	**[2]**	**[3]**	**[1*3]**	**[2*3]**	
1. Deforested land to tree planting	6,950	3,404	4,000	$27,800,000	$13,614,000	1.09
2. Degraded natural forest to Naturally regenerated forests	900	2,669	2,000	$1,800,000	$5,338,000	
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4. Degraded agriculture to Agroforestry	2,500	3,655	40,000	$100,000,000	$146,208,000	
5.Poor farm fallow to Improved farm fallow	2,300	264	1,000	$2,300,000	$263,800	

Step 3: Value change in ecosystem services – Interpret the results

- How much financing would be required to restore the landscape?
  - $162 million would be need to restore the landscape. This represents both material and labor costs

- How much revenue would be expected?
  - Restoring the landscape would generate $338 million over the restoration horizon (20 – 30 years)

- For every dollar invested in the restoration of this landscape how many additional dollars of benefits are created?
  - The results from the ROI framework suggest that each dollar invested in this landscape would yield $1.09 of additional benefits, including crops, timber, reduced erosion, and increased carbon sequestration.

Restoration Opportunity Assessment Geospatial Worksheet						
	Cost/ha	NPV	Area (M Ha)	Total cost	Total revenue	Landscape ROI
Restoration transition	**[1]**	**[2]**	**[3]**	**[1*3]**	**[2*3]**	
1. Deforested land to tree planting	6,950	3,404	4,000	$27,800,000	$13,614,000	1.09
2. Degraded natural forest to Naturally regenerated forests	900	2,669	2,000	$1,800,000	$5,338,000	
3. Degraded forest plantation to Silviculture	3,000	1,091	10,000	$30,000,000	$10,914,000	
4. Degraded agriculture to Agroforestry	2,500	3,655	40,000	$100,000,000	$146,208,000	
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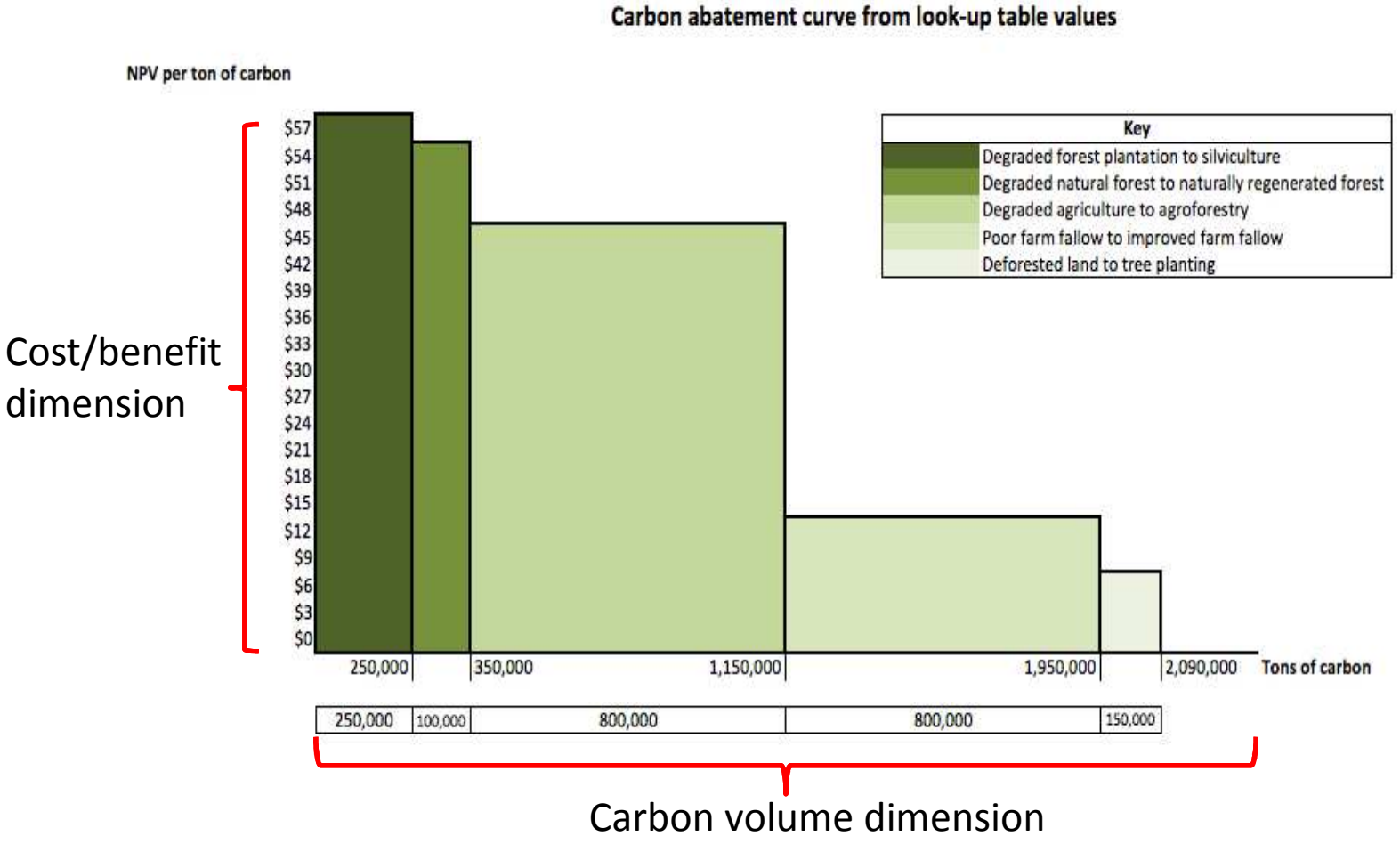
Constructing a carbon abatement curve

- Countries who use restoration to offset emissions want to find the least costly/most beneficial way to do so.
- Carbon abatement curves use information on the costs and benefits to estimate the costs/benefits of sequestering carbon under each restoration transition.
- The curves show how much carbon each transition could capture if all of the restoration opportunities were taken.

Two dimensions of a carbon abatement curve

- Cost (benefit) dimension: Height of curves show which restoration transitions sequester carbon for the least cost or most benefit.
- Volume dimension: The width of each bar represents the total amount of carbon that could be sequestered if all opportunity areas were restored.



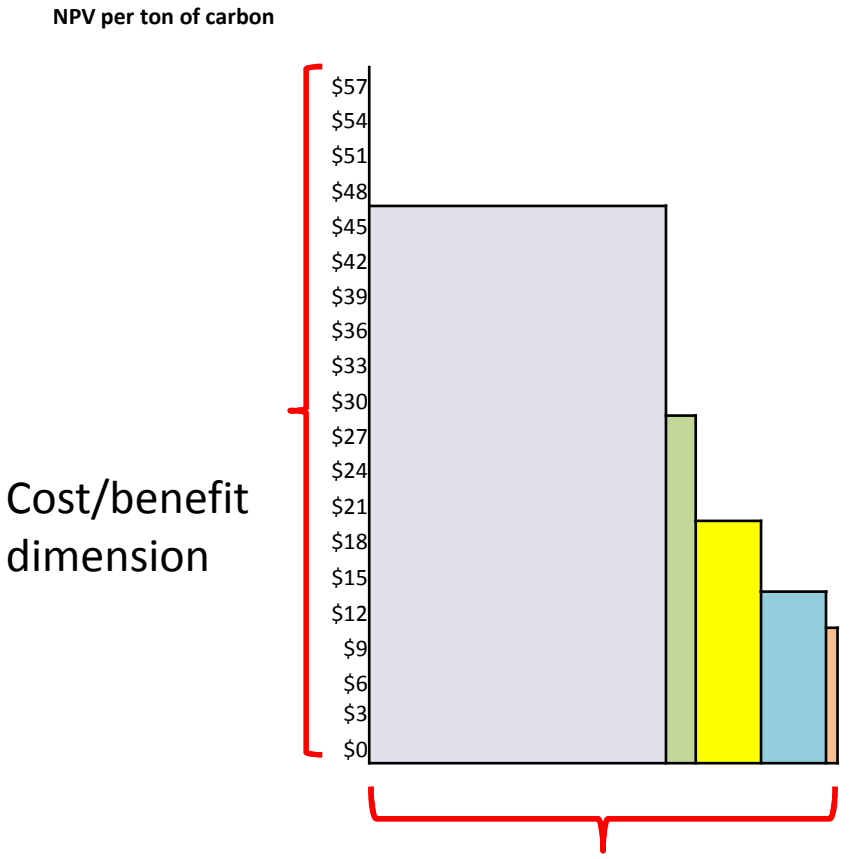
Constructing a carbon abatement curve

- To construct a carbon abatement curve we need to define the height and width of each restoration transition.
- Begin by creating a table that shows the amount of carbon, total area of opportunity, and the NPV for each restoration transition

Carbon Abatement Curve Worksheet					
Restoration transition	**Carbon (tons/ha)**	**Area**	**Total Carbon**	**NPV**	**NPV/TC**
	[1]	**[2]**	**[1*2]**	**[3]**	**[3/1]**
1. Deforested land to tree planting	150	4,000	600,000	$3,404	$23
2. Degraded natural forest to Naturally regenerated forests	100	2,000	200,000	$2,669	$27
3. Degraded forest plantation to Silviculture	60	10,000	600,000	$1,091	$18
4. Degraded agriculture to Agroforestry	80	40,000	3,200,000	$3,655	$46
5.Poor farm fallow to Improved farm fallow	20	1,000	20,000	$264	$13

- The total amount of carbon that can be stored (i.e. the width of each column) by each transition is found by multiplying the carbon sequestered by each hectare with the total number of hectares that could be restored.
- The cost (benefit) of carbon (i.e. the height of each column) is found by dividing the NPV of each transition by the tons of carbon stored by that transition on a single hectare.

Carbon Abatement Curve



Interpreting a carbon abatement curve

- Which restoration transitions have the potential to sequester the most carbon? Is that what you would have expected?
- If you were a social investor looking for a source of carbon offsets and community impact which restoration transition would you invest in?

Conclusions

- Given the amount of degraded land across the world, the ability to identify the most beneficial landscapes to restore is an important objective.
- An integrated approach that accounts for both the costs and benefits of restoration provides decision makers with more actionable information.
- Assessing the costs and benefits is useful for prioritizing investments in restoration across a variety of criteria including NPV, ROI, and multi-criteria decision-making.
- Restoration is most successful when planning is based on multiple factors, in addition to economic ones.
- Other factors (e.g. secure land-tenure) will also be key to restoration success. Restoration is most likely to succeed.