



Costs and benefits of forest restoration - ecological, social, and economic

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Outline

- Cost
 - Time
 - Financial
 - Benefits
 - Products
 - Water services
 - Carbon sinks
 - Biodiversity conservation
 - Opportunities for ecotourism
- Production, management, restoration, collaboration

Cost-Time

- Conception/management – meetings
- Administration – regulation, dispute resolution, reporting, accounting, benefit sharing
- Training



Cost-Financial

- Legal/admin fees
- Survey costs – baseline carbon, timber and NTFP's
- Forest maintenance/ management – paid labour or voluntary?
- Particularly FIRE PREVENTION



Production Value Foregone



4 NATIONAL

Rubber growers plan rally over price drop



Production Value Foregone

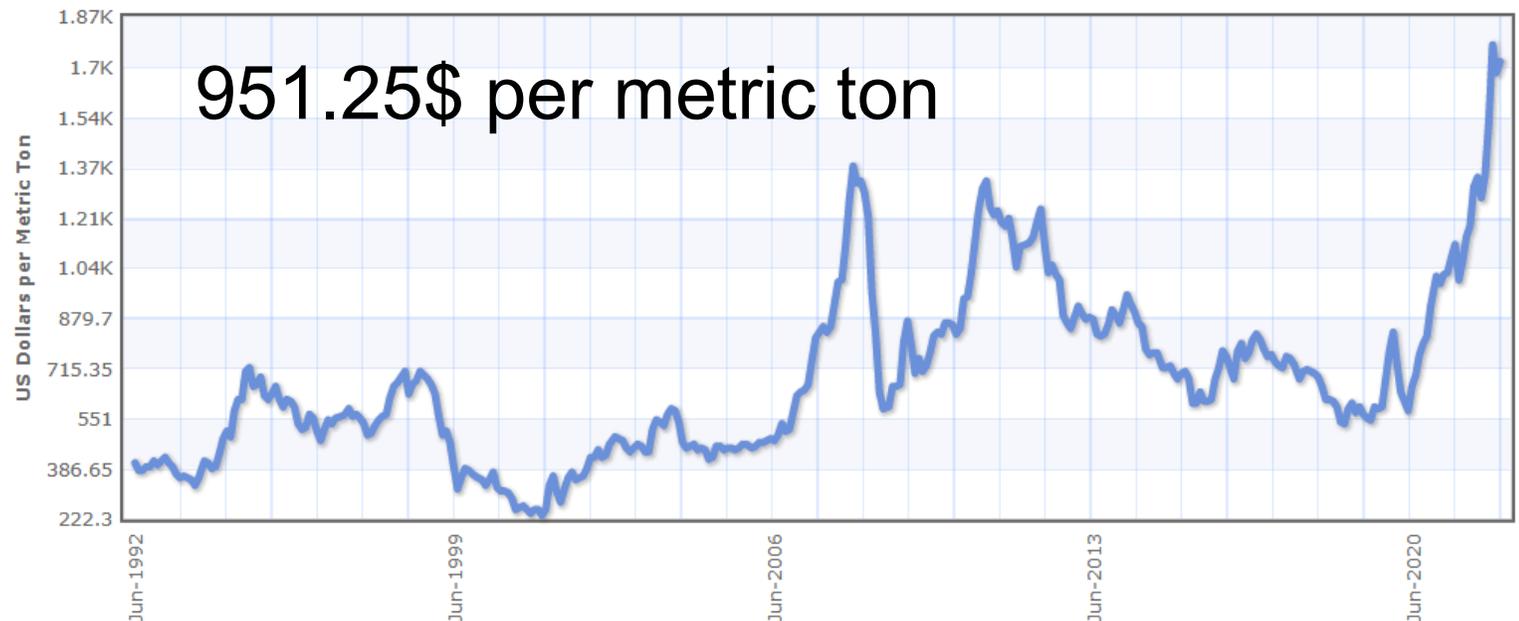
S. Thailand – current income from oil palm about 600 US\$/ha/y from 7 to 15 years after plantation establishment.



Palm oil Monthly Price - US Dollars per Metric Ton

Range 6m 1y 5y 10y 15y 20y 25y 30y

Jun 1992 - May 2022: 1,312.920 (324.98%)



Restoration cost

- Pre-planting rapid site assessment

Measures the density and species richness of natural regeneration and identifies factors impeding its progress

- Collaborative Costing



Restoration cost

- Pre-planting survey
- Site preparation
- Tree planting
- Weeding/fertilizer
- Monitoring for two years
- Fire prevention for two years
- Livestock exclusion
- Reporting / accounting

The cost of forest restoration depend in location

1. The degree of degradation
2. Distance to restoration site
3. Local daily labor rate (9.5\$ per day in Chiang Mai)



Restoration cost

Example

Local cost parameter

1. Survey, estimated no. of existing natural regenerant per ha	1000 per ha
Therefore, the recommended number of tree to plant is	2086 per ha
2. Distance from nursery to restoration site & return	30 km
Distance from homebase to restoration site & return	30 km
Current price of liter of fuel	35 THB
Enter the average fuel efficiency of vehicles to be used in km/liter	12 km/l
3. Daily labor rate	346 THB
Salary of project staff/supervisor	18,000 THB
Total area to be restored	20 ha
Enter the annual inflation rate (forecast for next 2 years)	3% /y

THB

???

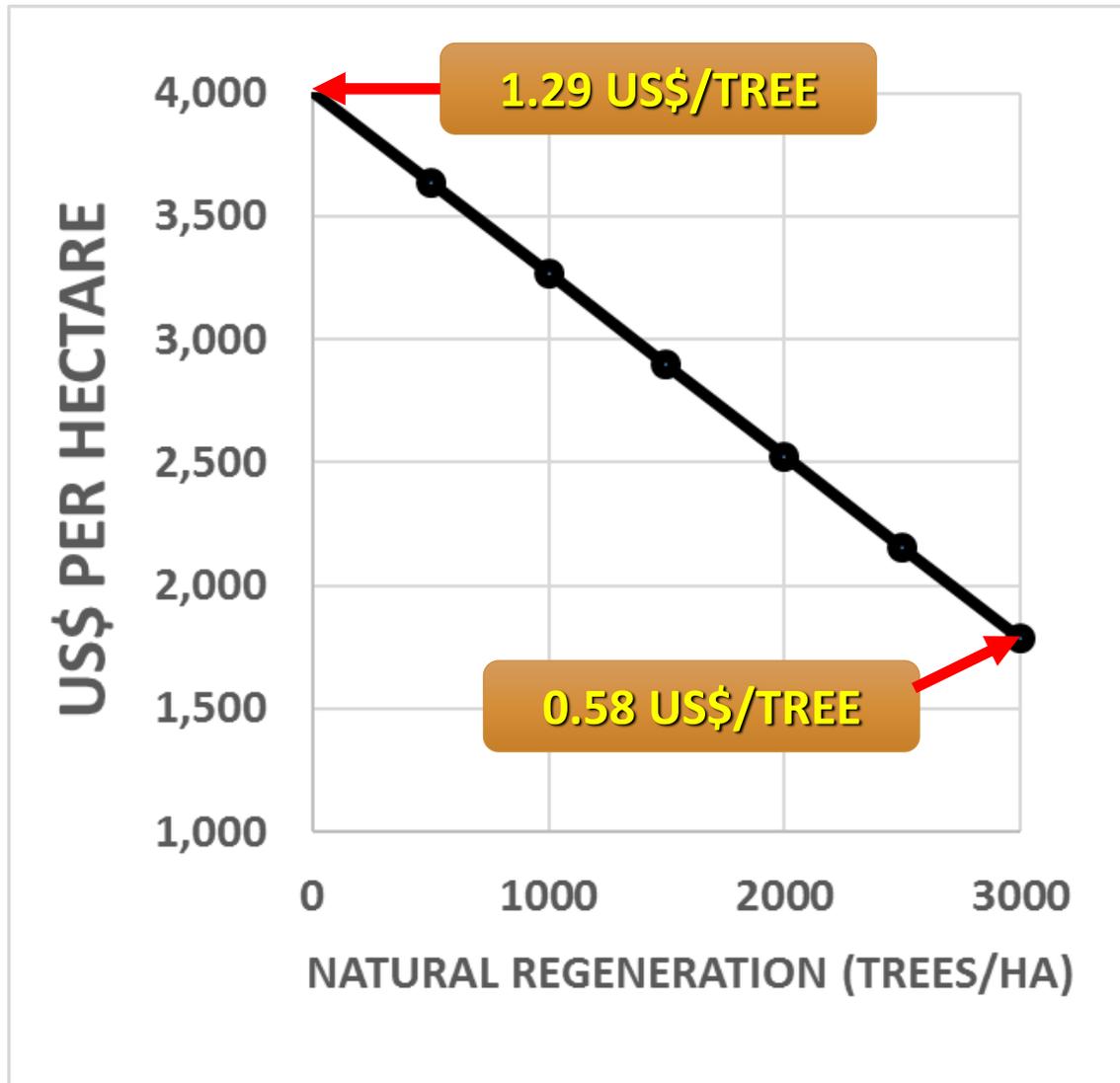


Restoration cost

=170,569 THB

DE	#Units	UNITS	Cost/Unit	Costs		TOTAL	Details
				1ST YEAR	2ND YEAR		
Pre-planting site survey							
Vehicle hire	1	VEHICLE	1,700	1,700	0	1,700	ENTER ZERO UNITS IF USE OWN VEHICLE
Fuel	30	KM	3	75	0	75	
Equipment	1	SET	300	300	0	300	
Project management staff inputs - supervision data analysis	2	DAYS WORK	818	1,636	0	1,636	
Site preparation - weeding spraying							
Weed slashing labour	375	DAYS WORK	310	116,250	0	116,250	Assuming labourers bring their own tools. Slash weeds down to 10-20 c, 6 weeks before tree planting.
Herbicide spraying labour	20	DAYS WORK	465	9,300	0	9,300	spray glyphosate on new weed shoots 3 weeks before tree planting.
Glyphosate	50	GALLON	550	27,500	0	27,500	2.5 gallon per hectare (@550 PER GALLON)
Supervision weeding/spraying vehicle hire	1	VEHICLES	1,700	3,400	0	3,400	ENTER ZERO UNITS IF USE OWN VEHICLE. Two trips weed slashing and herbicide application.
Supervision weeding/spraying vehicle fuel	30	KM	3	150	0	150	
Project management staff inputs - training, supervision, payments, accounting.	2	DAYS WORK	818	1,636	0	1,636	
Seedling transfer to site - labour	28	DAYS WORK	310	8,622	0	8,622	
							500 trees per 1 load, cost is per trip. Usually we

Restoration cost



- Daily labour 10 us\$/day
- Site survey and planning
- Trees and planting
- Weeding and fertilizer application for 2 years + fire prevention.

Benefits

- Products
- Water services
- Carbon sinks
- Biodiversity conservation
- Opportunities for ecotourism



Non-Timber Forest Product (NTFP)

At least 150 different forest products, including rattan, bamboo, nuts, essential oils and pharmaceuticals, traded internationally, contribute about US\$ 4.7 billion/year to the global economy.



Compared with **NATURAL RUBBER**
13.1 billion US\$ (2018)

-22.1% drop in value since 2014 when natural rubber shipments were worth \$16.8 billion. Year over year, exported natural rubber depreciated by -19.9% from 2017 to 2018



Non-Timber Forest Product (NTFP)

But NTFP trade requires

- Sustainable management, by monitoring and research
- Appropriate land tenure, taxation and legislative systems
- Access to global markets – promotion advertising
- Integration of traditional knowledge into NTFP research and management



Non-Timber Forest Product (NTFP)

- Some forest-dwelling people depend on forest products for subsistence – but the numbers are probably declining.
- More often, gathering or selling such products provides a safety net for the rural poor when times are bad

Value is quantified as “replacement” costs



Achieving Sustainable Harvesting

- Measure standing crop and growth rate
- Annual harvest must be $<$ annual production
- Calculate quotas
- Issue permits
- Record total harvest (weight) and harvest “effort” (usually time).
- Enforcement – dealing with transgressors
- Cost of administration $>$ income from product?



Achieving Sustainable Harvesting

Danger in relying on NTFP's as forest "value"

- Trend is often towards **domestication** – which can provide an incentive to deforest
- Exception – mycorrhizal fungi which grow associated with forest trees





Subsistence products



Replacement products

Traded products

GDP

GDP rise
=> economic growth

GDP rise
=> Recession

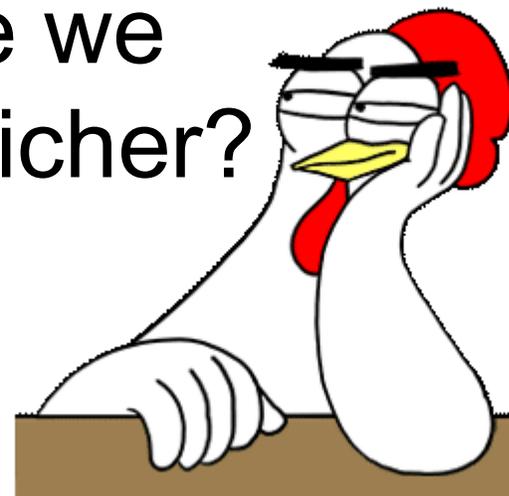


Sell logs



Pay wages

But are we
really richer?



Productive forest



NTFP's
Water
Carbon storage
Biodiversity

Degraded forest



Few usable products
Soil erosion
Global warming
Species loss

What about local people?



GDP rises but they are poorer



- Forest destruction always results in net economic loss at the national and local levels.
- By measuring prosperity by GDP, we don't value all the benefits of forests.
- So should governments invest in forest restoration?



Watershed Services

- Deforestation increases water yield, but outflow becomes more seasonal.
- Tropical forests add enormous quantities of organic matter to soils, which increases their field capacity
- Such soils soak up water during the rainy season (reducing floods) and release it gradually during the dry season (reducing droughts).



Watershed Services

- Deforestation exposes the soil to erosion and compaction. Absorptive top soil is rapidly lost. **Infiltration** is reduced and **runoff** increases, resulting in flash floods & landslides

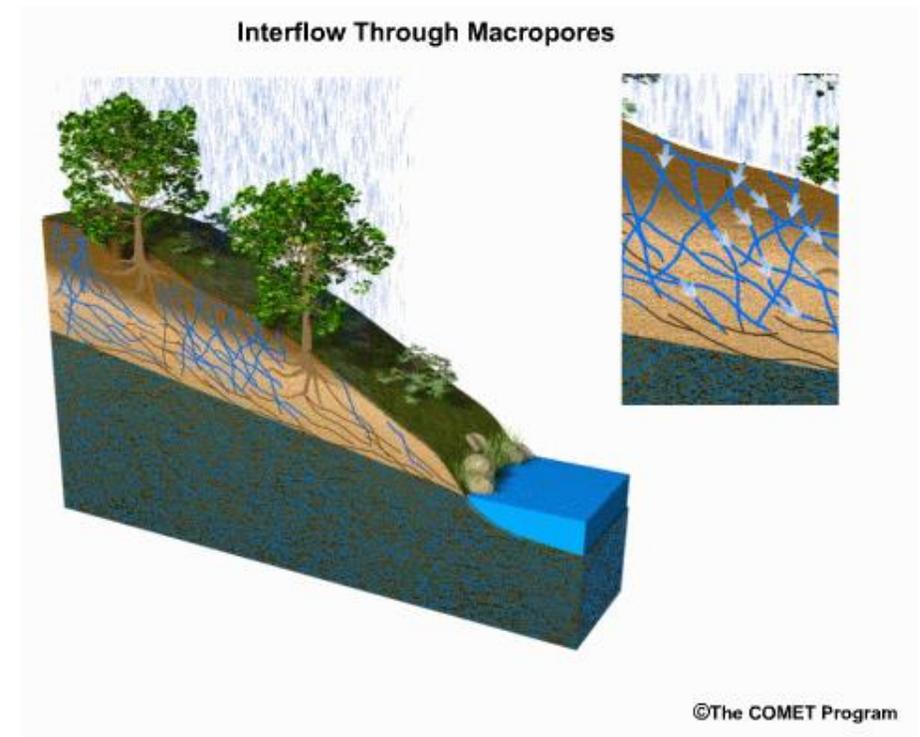
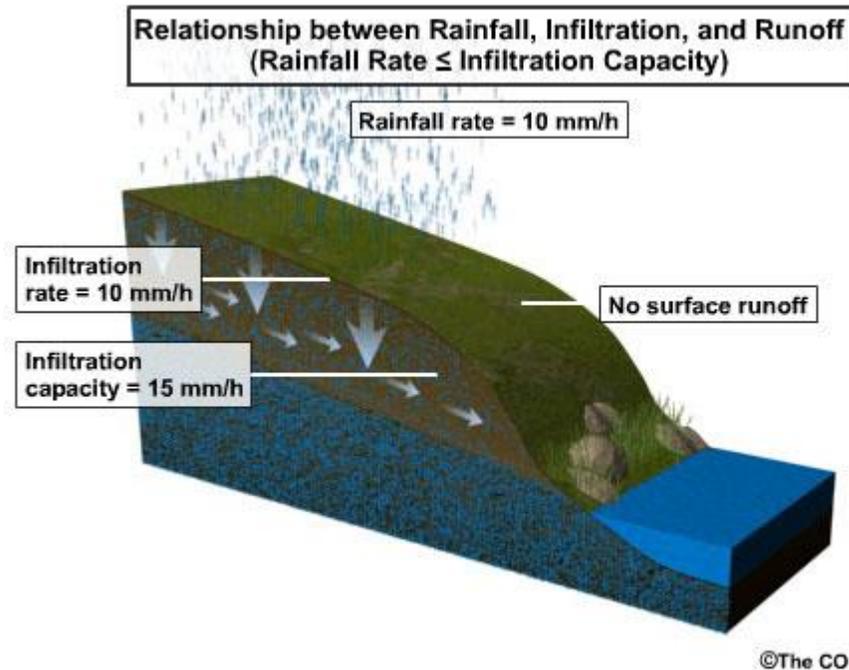


Table 4.

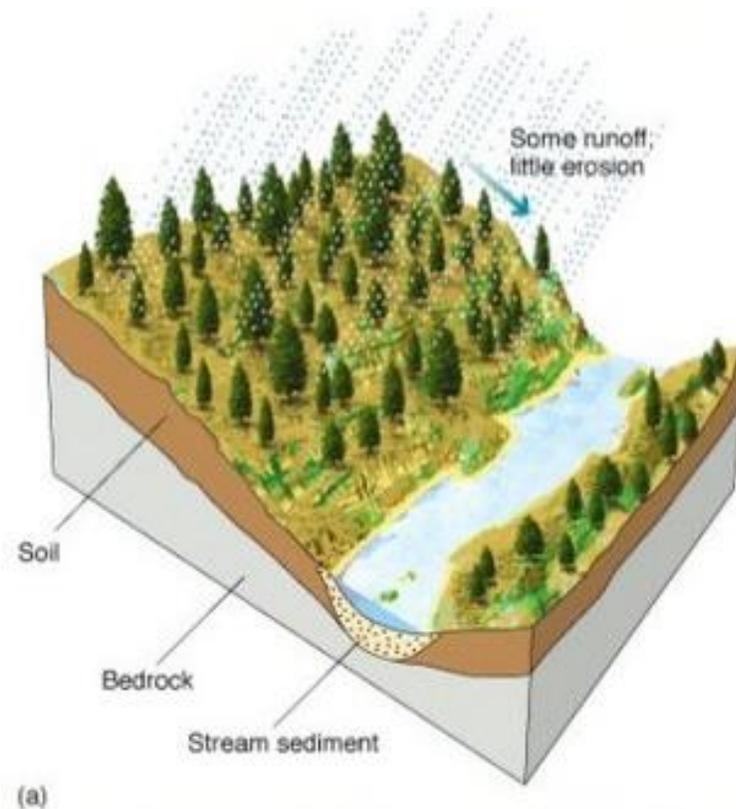
Relationships between surface runoff, soil erosion and canopy cover. From Ruangpanit (1985)

Crown cover%	Surface runoff (m³ ha⁻¹)			Soil erosion (kg ha⁻¹)		
	Total*	Average	Cumulative	Total	Average	Cumulative
20-30	194.2	4.7	21.8	652.8	15.9	62.8
40-50	177.8	4.3	17.1	512.3	12.5	46.9
50-60	183.4	4.5	12.8	456.9	11.1	34.4
60-70	113.2	2.8	8.3	372.5	9.1	23.3
70-80	121.3	3.0	5.5	298.0	7.2	14.2
80-90	102.3	2.5	2.5	285.1	7.0	7.0

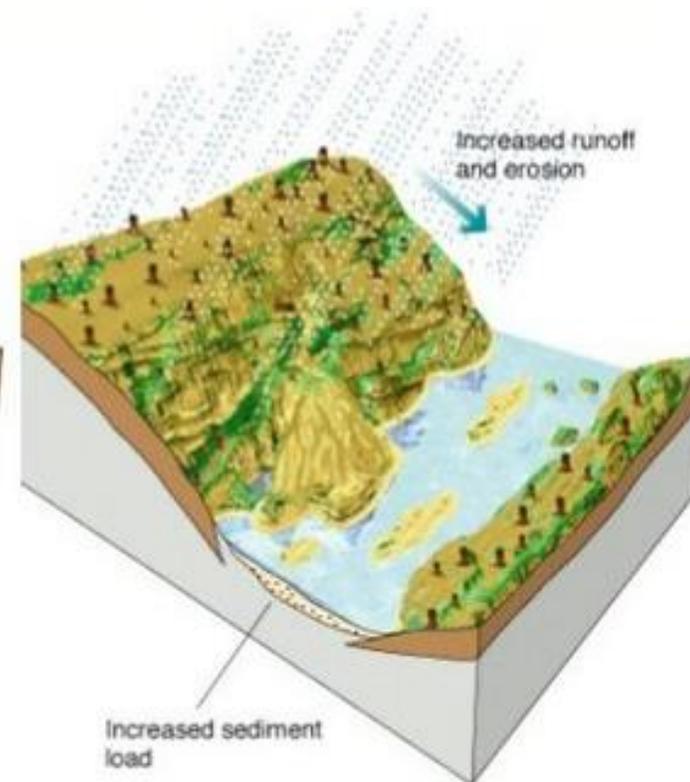
* For 41 runoff-producing storms totalling 1 128 mm rainfall.

Watershed Services

Flow is lower but more constant in all seasons.
Sedimentation low.

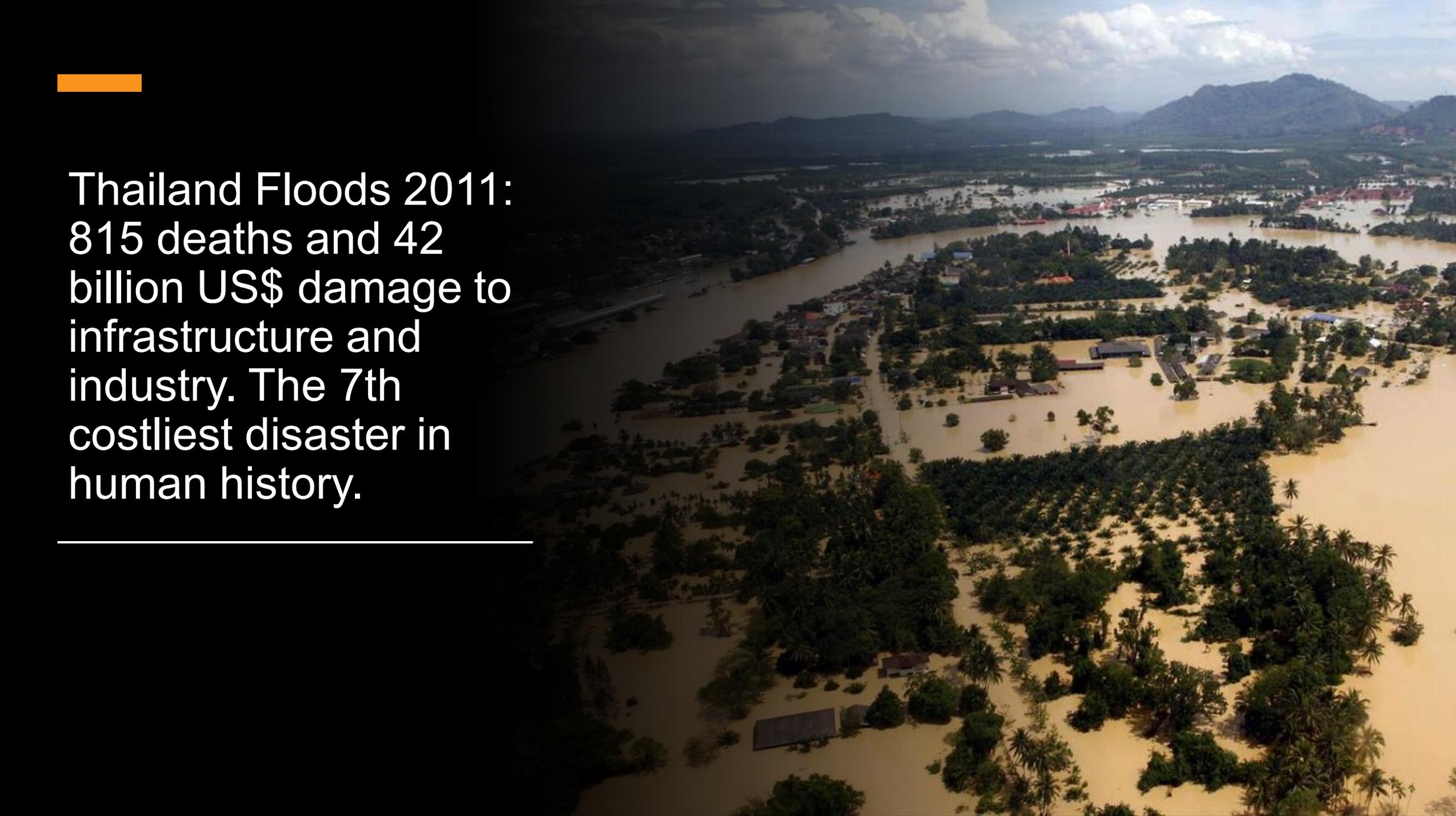


Flow is higher in rainy season.
High sedimentation begins to reduce river channel volume.



Increased runoff + reduced river channel volume
= Flash floods

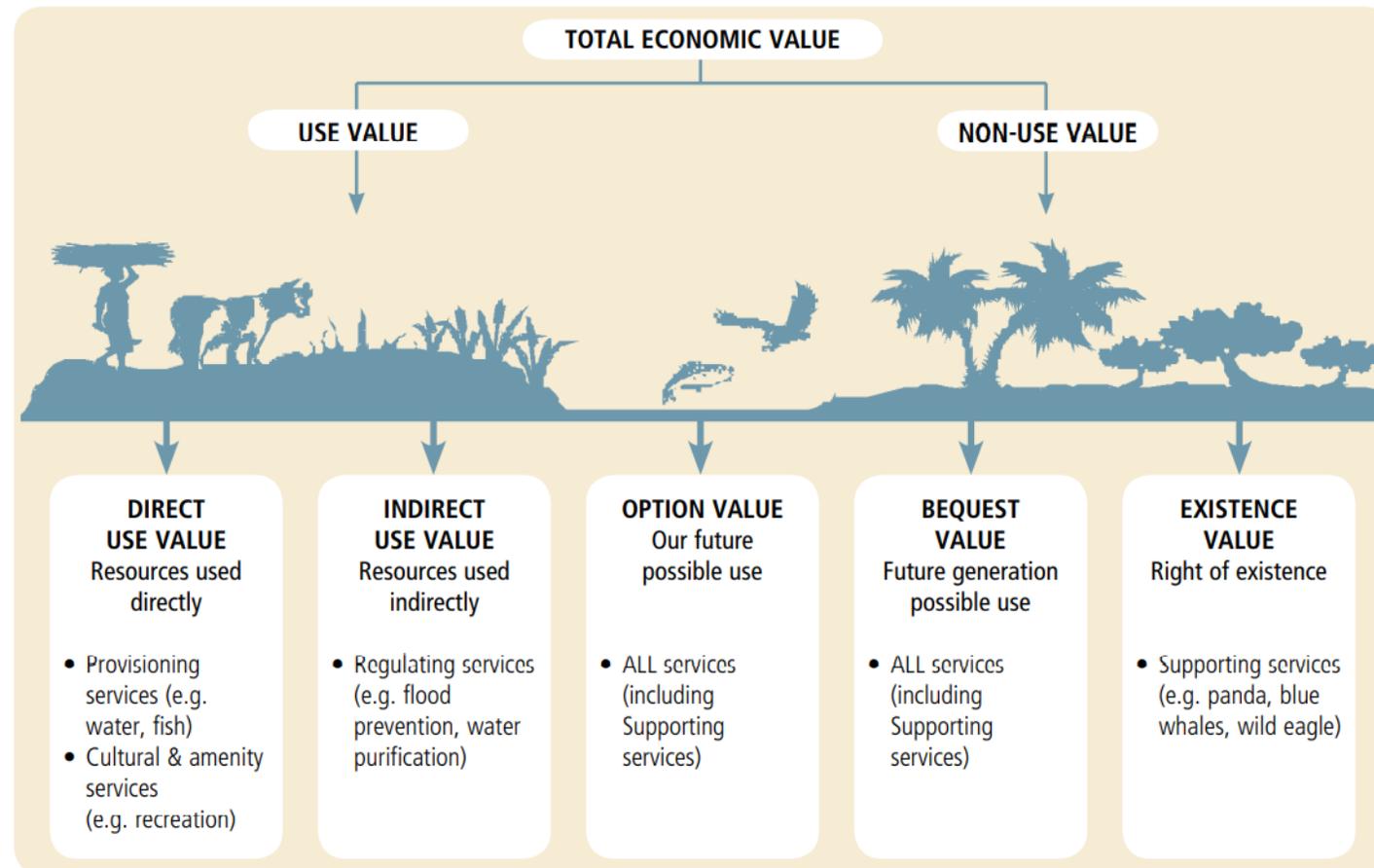


An aerial photograph showing a vast area of flooding in a rural region of Thailand. The water is a muddy, brownish-yellow color, inundating fields, roads, and some buildings. In the background, there are rolling hills and mountains under a cloudy sky. The foreground shows a dense line of palm trees and other tropical vegetation partially submerged in the floodwater.

Thailand Floods 2011:
815 deaths and 42
billion US\$ damage to
infrastructure and
industry. The 7th
costliest disaster in
human history.

How to monetarize watershed services?

1. Linking land and water use to downstream benefits
2. Valuation of watershed services



Service type	Service provided	Developed economies (US\$/ha/year)	Developing economies (US\$/ha/year)
Provisioning services	Water for people	45 - 7500	50 - 400
	Fish/shrimp/crabs	200	6 - 750
	Agriculture and grazing	40 - 520	3 - 370
	Wildlife (for food)	40 - 520	0.02 - 320
	Vegetables and fruits	40 - 470	1 - 200
	Fibre/organic raw material	45	1 - 40
	Medicinal plants		6
	Inorganic raw material	15 - 160	0.1
Regulating services	Water quality control	60 - 6700	20 - 1400
	Flood mitigation	15 - 5500	2 - 1700
	Groundwater replenishment		10 - 90
	Erosion control		20 - 120
	Carbon sequestration	130 - 270	2 - 2000
	Microclimate stabilization		10
Supporting services	Biodiversity conservation		0.6 - 3600
Cultural and amenity services	Recreation and tourism	230 - 3000	20 - 260
	Cultural/religious activities	30 - 1800	80

Upstream landowner
Service seller

Land use activities or state

Hydrological effects

Watershed services
(e.g. water, quantity, quality, timing)

Downstream community
Service buyer

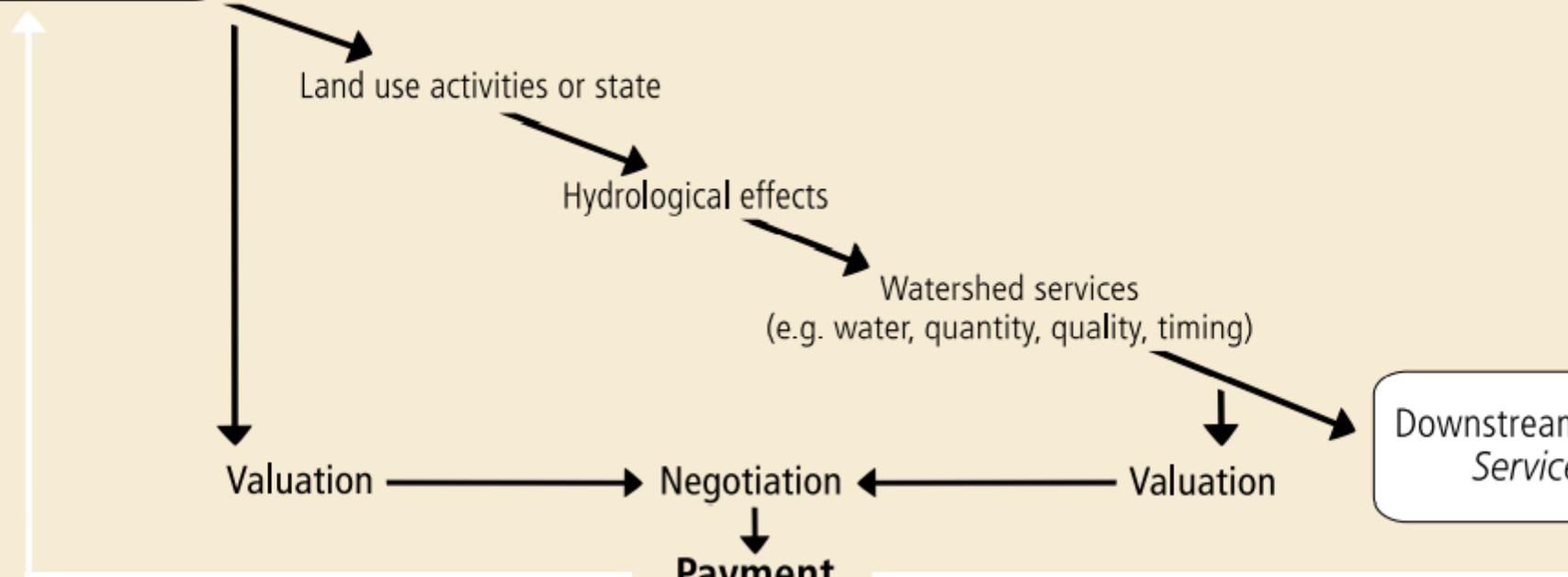
Valuation

Negotiation

Valuation

Payment

Improved watershed services to downstream community

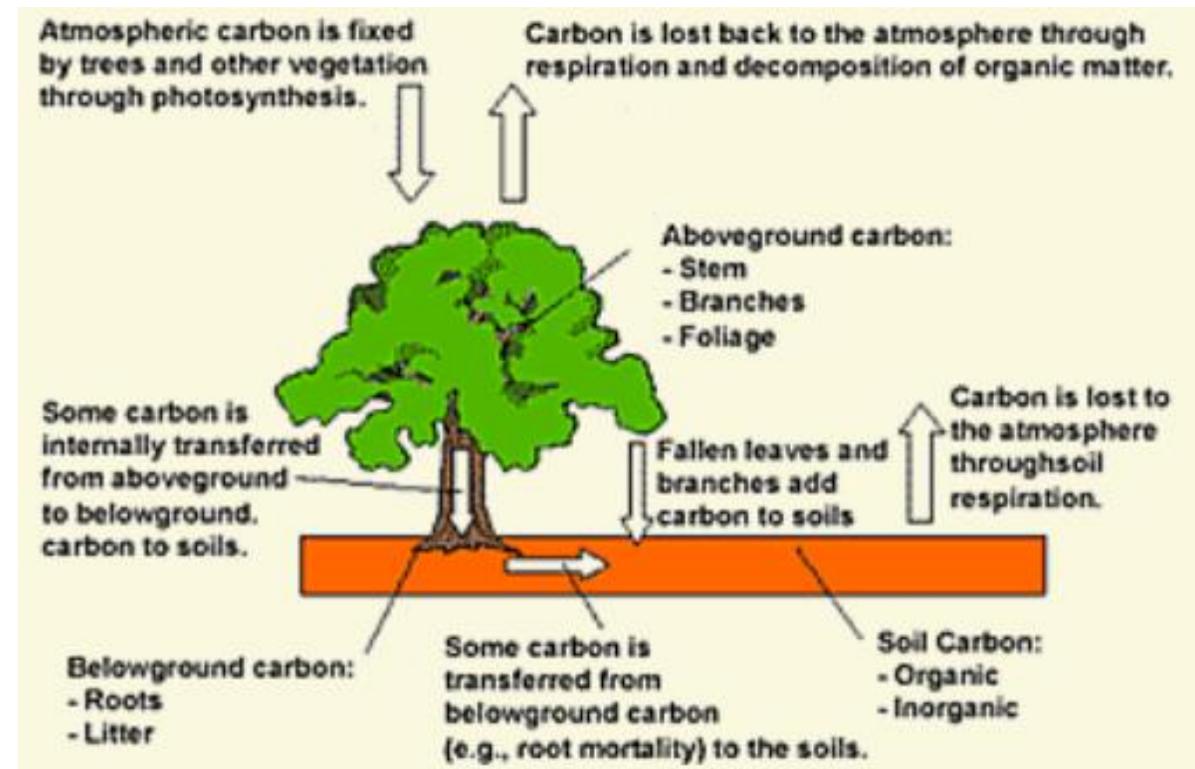


Carbon sink

Tropical forests absorb more CO₂ than they emit about 1.3 gigatonnes* of carbon (GtC) per year (Lewis et al., 2009)

= 16.6% of carbon emissions from burning fossil fuels and the cement industry

= 60% of the sink provided by all of the terrestrial vegetation on Earth.

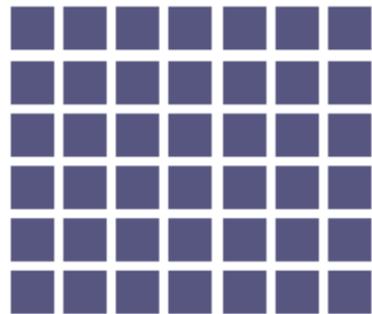


Carbon sink

The amount of carbon stored by 2100 depends on which type of forest restoration the 43 Bonn Challenge countries in the analysis decide to adopt, across a total area of 350 million hectares (Mha).

■ = 1 petagram of carbon

All land becomes forest naturally



42 petagrams of carbon stored in 350 Mha

This is the most effective way to retain carbon.

Current plans are maintained

With protection of natural forest



16

No protection of natural forest



3 (assuming naturally regenerated forests are converted to biofuel plantations in 2050)

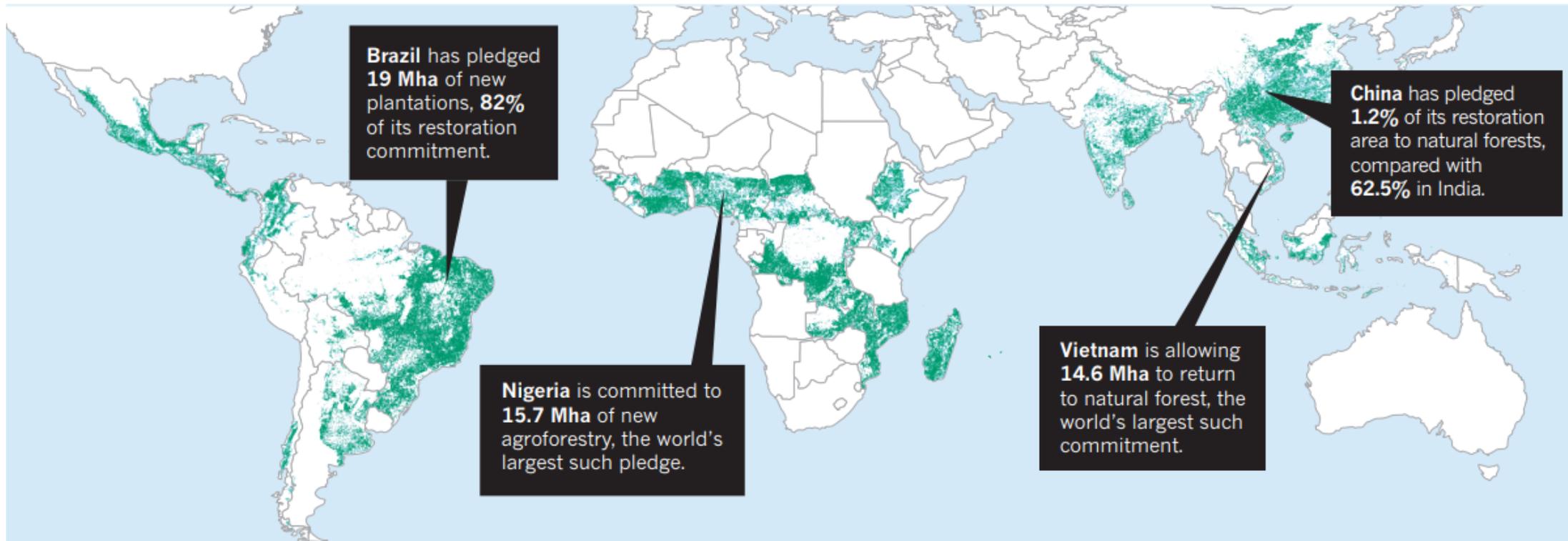
All land becomes plantations



1

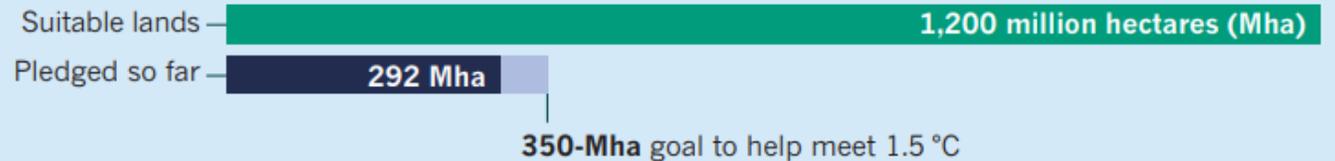
“ ... natural forests are 6 times better than agroforestry and 40 times better than plantations at storing carbon (sequestering 12, 1.9 and 0.3 Pg C per 100 Mha by 2100, respectively). ”

Carbon sink



RESTORATION POTENTIAL

Under the Bonn Challenge and national schemes, 43 countries in the tropics and subtropics — where tree growth is fast — have pledged to restore forests to sequester carbon. Creating the right type of forest on one-third of their suitable lands could help to keep global warming to within 1.5 °C.



Carbon sink

- Tropical forests store about 240 tC/ha in trees/soil.
- Crop lands - 80 tC/ha mostly in soil.
- Clearing 1 ha of tropical forest emits about 160 tC & also reduces subsequent sequestration rate.
- Agriculture also releases methane, which is 20 times more efficient at trapping heat than CO₂ is.

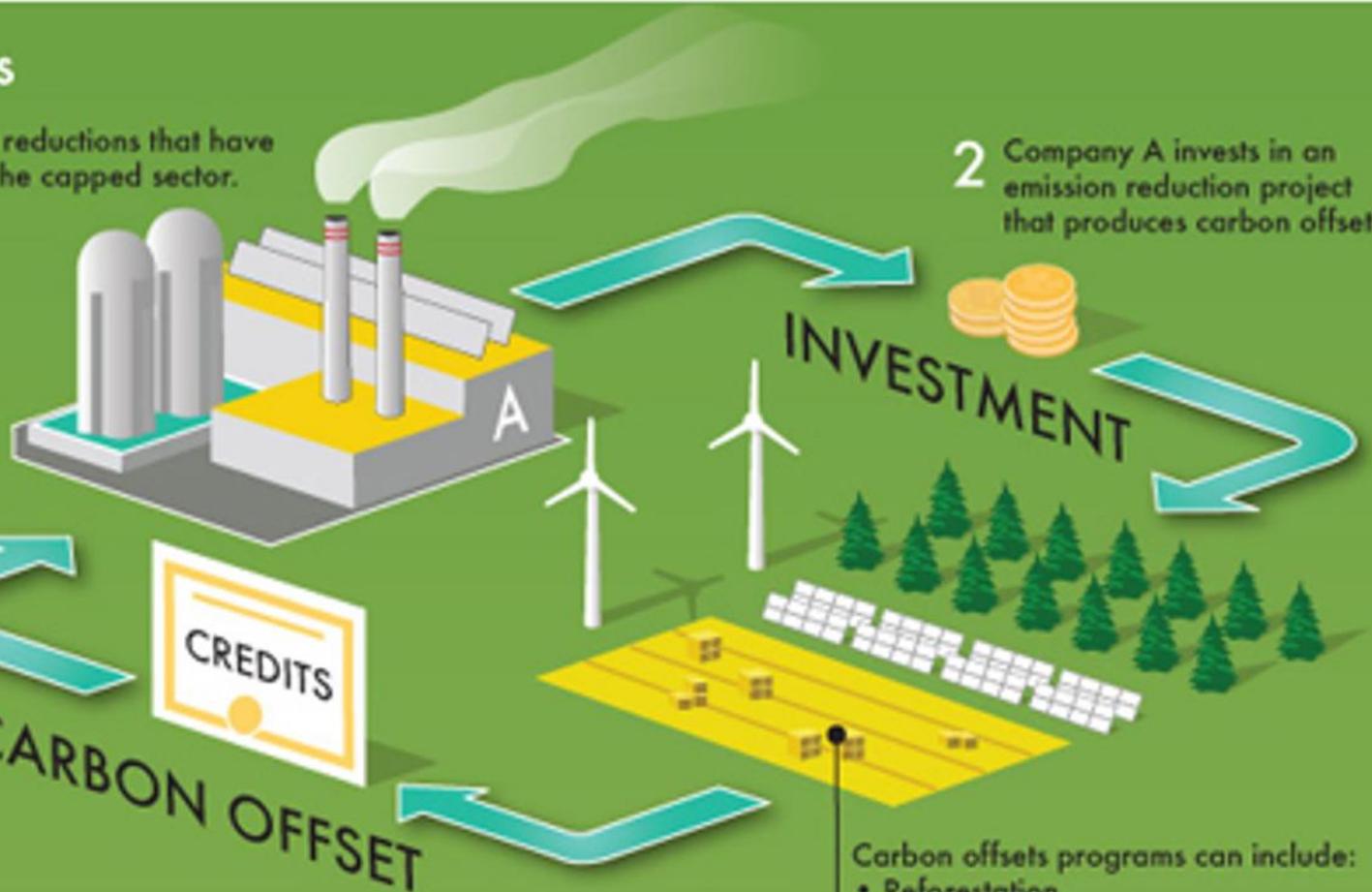


How to monetarize carbon – carbon credits

Carbon Offsets

Offsets represent emission reductions that have been achieved outside of the capped sector.

1 Company A needs to meet its emissions cap



2 Company A invests in an emission reduction project that produces carbon offsets

3 Company A receives carbon credits for its investment

One carbon credit = One tonne of greenhouse gas emission reductions

- Carbon offsets programs can include:
- Reforestation
 - Renewable energy
 - Methane capture/combustion



An aerial photograph of a dense, green forest with a winding river or stream cutting through it. The water is a light blue-green color, and the surrounding land is covered in thick, vibrant green trees.

Type of Carbon Credits

- Compliance credits (CER's) – governments and corporations legally obliged to buy credits to meet targets set by national laws.
- Voluntary Credits (CCX's or CRT's) – individuals or organizations taking responsibility for their own carbon footprints.

Type of Carbon Credits

Emission Trading Scheme & Types of Carbon

http://www.climatechange.lk/DNA/carbon_market.html

Name of the emissions trading scheme		Name of the carbon credit	Traded volume (MtCO ₂ e)	Market value (MU\$)	
Regulatory Compliance	Kyoto Mechanism	Clean Development Mechanism (CDM) Certified Emission Reduction (CER)	Primary CER	211	2,678
			Secondary CER	1,055	17,543
		Joint Implementation (JI)	Emission Reduction Units (ERU)	26	354
		Emissions Trading (ET)	Assigned Amount Units (AAU)	155	2,033
		European Union Green House Gas Emission Trading System (EU ETS)	EU Allowance (EUA)	6,326	118,474
		New South Wales Greenhouse Gas Reduction Scheme (NSW-GGAS)	NSW Greenhouse Abatement Certificates	34	117
		Regional Greenhouse Gas Initiative (RGGI)	RGGI Allowance	813	2,667
Voluntary	Over the Counter Voluntary Emission Reduction			51	326
	Chicago Climate Exchange	CCX Carbon Financial Instruments (CFI)		41	50
	Other Exchanges			2	12

Carbon credits are traded on international markets. Prices fluctuate a lot! But unlike rubber and palm oil, the recent trend is UP.





Restoration by framework species method: carbon in trees goes back to normal levels in about 16 years

Increase in above-ground tree carbon with time since planting framework tree species

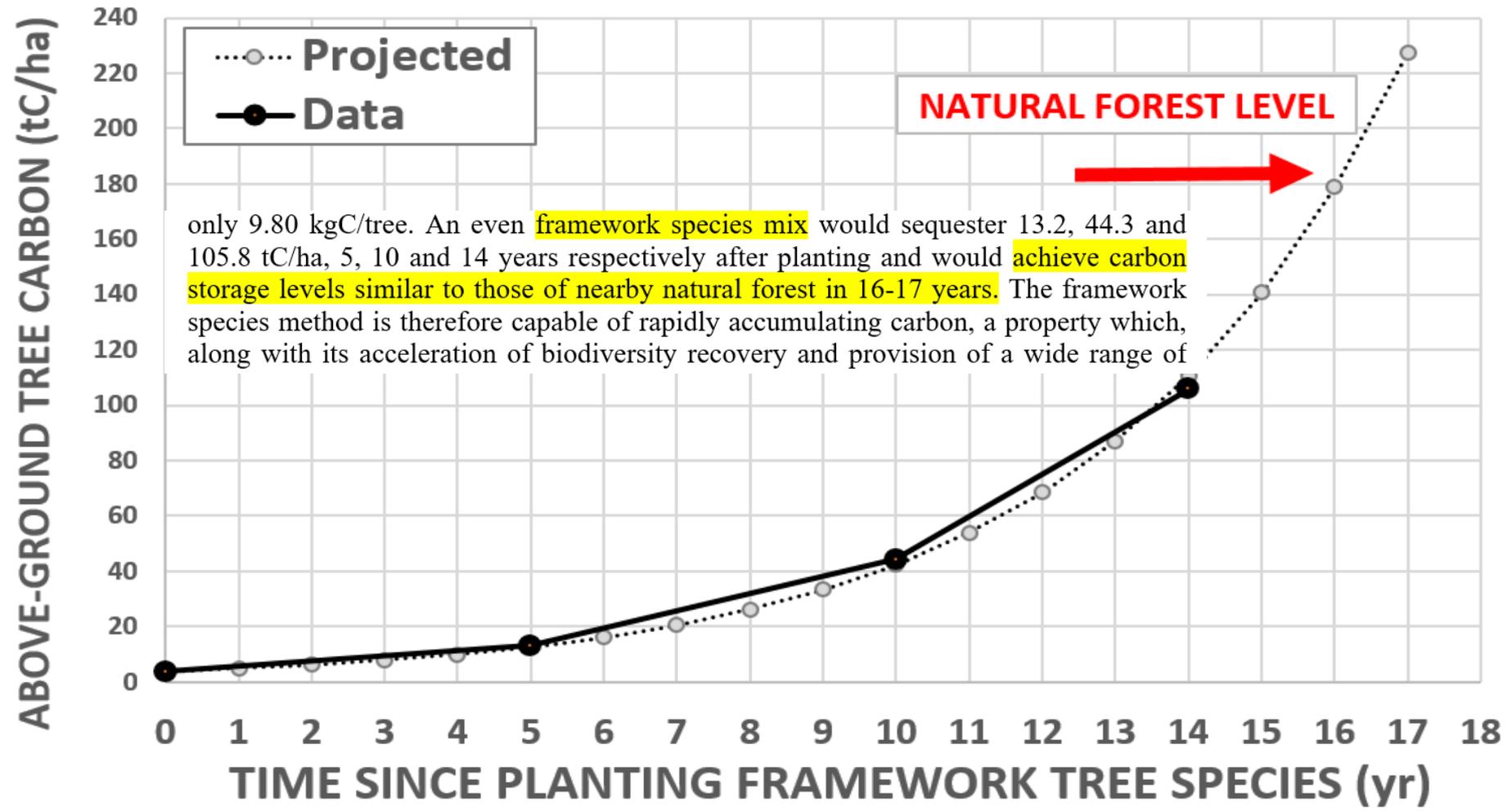




Table 2. Potential value of incremental tree carbon, during restoration of upland evergreen forest in northern Thailand by the framework species method.

Forest Age (Since Start of Restoration)	Tree Carbon Stock ¹	Increment	Increment Potential Cash Value ²
(Year)	(tC/ha)	(tC/ha)	(USD)
0	1.73	-	-
5	18.04	16.31	3950.39
10	60.75	42.71	10,344.65
14	144.81	84.06	20,359.90
Total (0–14 Y)		143.08	34,654.95

- Using The framework species method, profits from carbon sequestration over 14 years ranged in NPV from 22,215.45 to 25,157.04 US\$/ha.
- Profits from maize cultivation (a major regional deforestation driver) averaged just 1,347.53 US\$/ha over 14 years,



REDD policy

Policies and incentives under the UN Framework Convention on Climate Change to reduce CO₂ emissions from clearing/burning forests.

REDD = **R**educing **E**missions from **D**eforestation & **D**egradation

It is paying people NOT to cut or burn forests **but People who had no intention of clearing forest, may start deforestation to get payments.**



REDD policy

“...enhancement of carbon stocks ...” COP15 2009 4CP/15.

REDD to REDD++

- Include forest restoration to absorb CO₂ by tree planting or assisting natural regeneration
- Include “full and effective engagement of indigenous people and local communities ...”
- Include “... consistent with conservation of natural forests and biodiversity ...”

Biodiversity

Biodiversity → NTFP diversity → economic adaptability → security

- Pollinators support agriculture

Abstract

Can economic forces be harnessed for biodiversity conservation? The answer hinges on characterizing the value of nature, a tricky business from biophysical, socioeconomic, and ethical perspectives. Although the societal benefits of native ecosystems are clearly immense, they remain largely unquantified for all but a few services. Here, we estimate the value of tropical forest in supplying pollination services to agriculture. We focus on coffee because it is one of the world's most important export commodities and to ensure the

many of the replicated d yields by 20 by reducing 2000–2003, translated in commensur

current conservation incentive payments. Conservation investments in human-dominated landscapes can therefore yield double benefits: for biodiversity and agriculture.

Economic value of tropical forest to coffee production

Taylor H. Ricketts, Gretchen C. Daily, Paul R. Ehrlich, and Charles D. Michener [Authors Info & Affiliations](#)

August 11, 2004 | 101 (34) 12579-12582 | <https://doi.org/10.1073/pnas.0405147101>

by reducing the frequency of “peaberries” (i.e., small misshapen seeds) by 27%. During 2000–2003, pollination services from two forest fragments (46 and 111 hectares) translated into ≈\$60,000 (U.S.) per year for one Costa Rican farm. This value is

Biodiversity

- Wildlife tourism
 - 1-day Bird Tour Khao Yai: 66 – 237 US\$/day

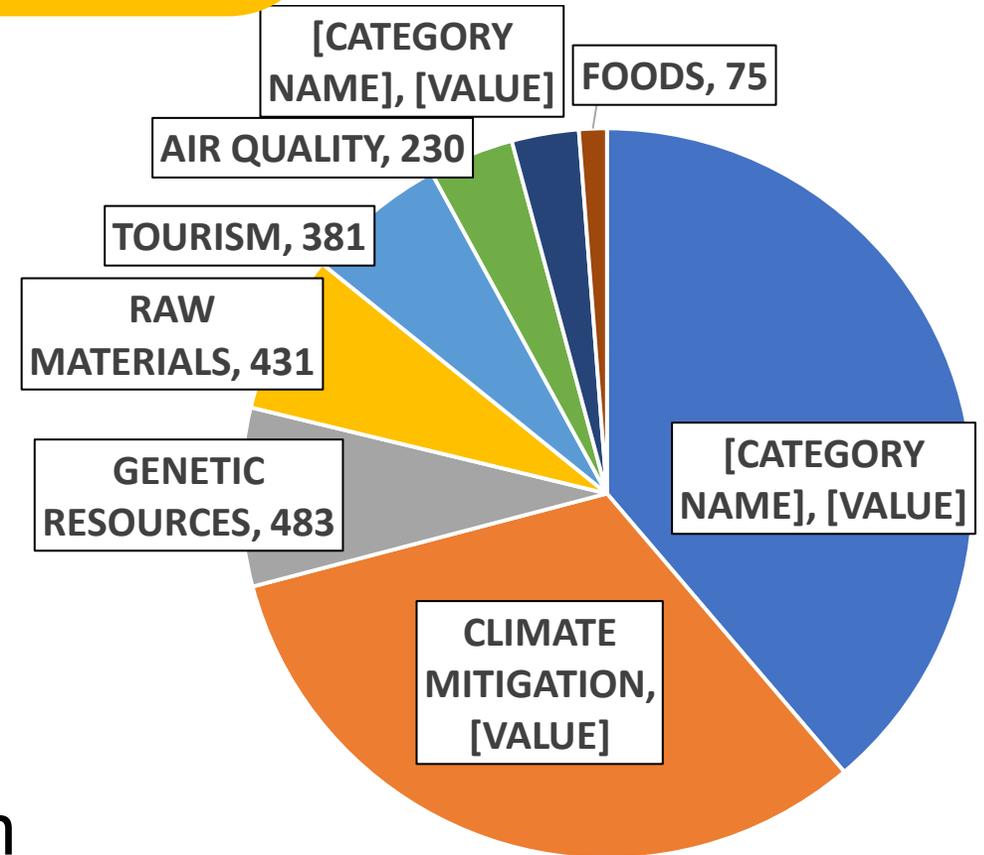


DIVERSITY REDUCES RISK

Potential value of ecosystem products/services from 1 ha of tropical forest (US\$/y)

TOTAL = 6,120 US\$/ha/y

S. Thailand – current income from oil palm about 600 US\$/ha/y



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