

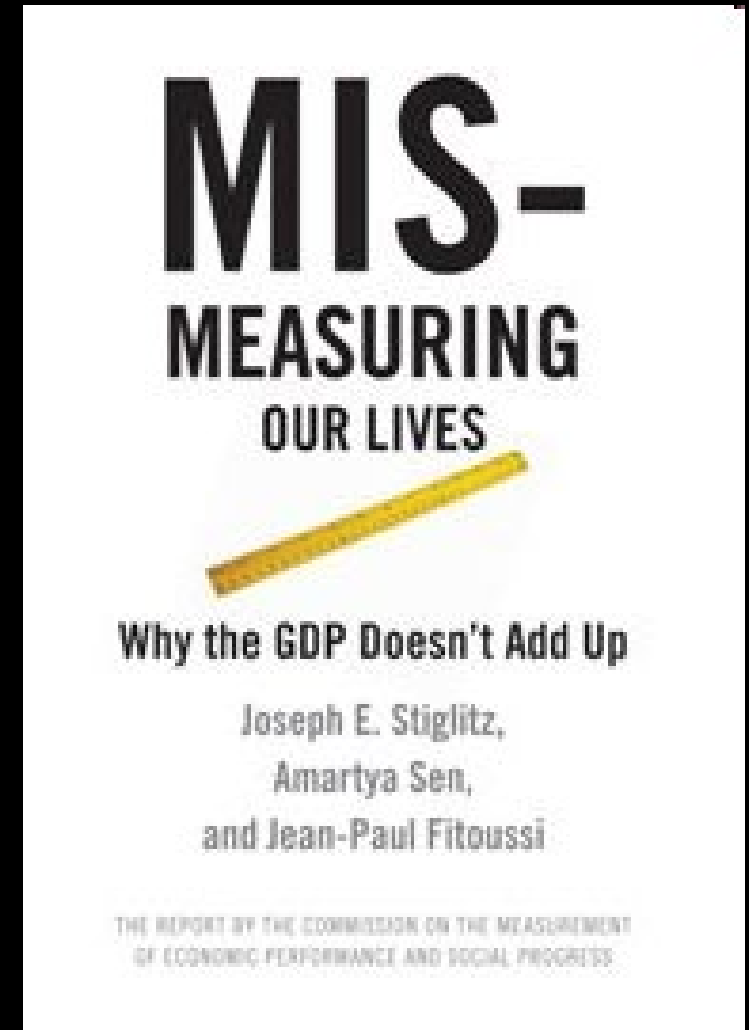
Gross Ecosystem Product (GEP)

A scenic landscape photograph of a calm lake reflecting the surrounding dense forest and mountains. The text 'Gross Ecosystem Product (GEP)' is overlaid in the center. The lake is perfectly still, acting as a mirror for the lush green forest on the slopes and the distant mountain peaks. The sky is a pale, clear blue, and the overall atmosphere is peaceful and natural.

Photo: Stephen Polasky

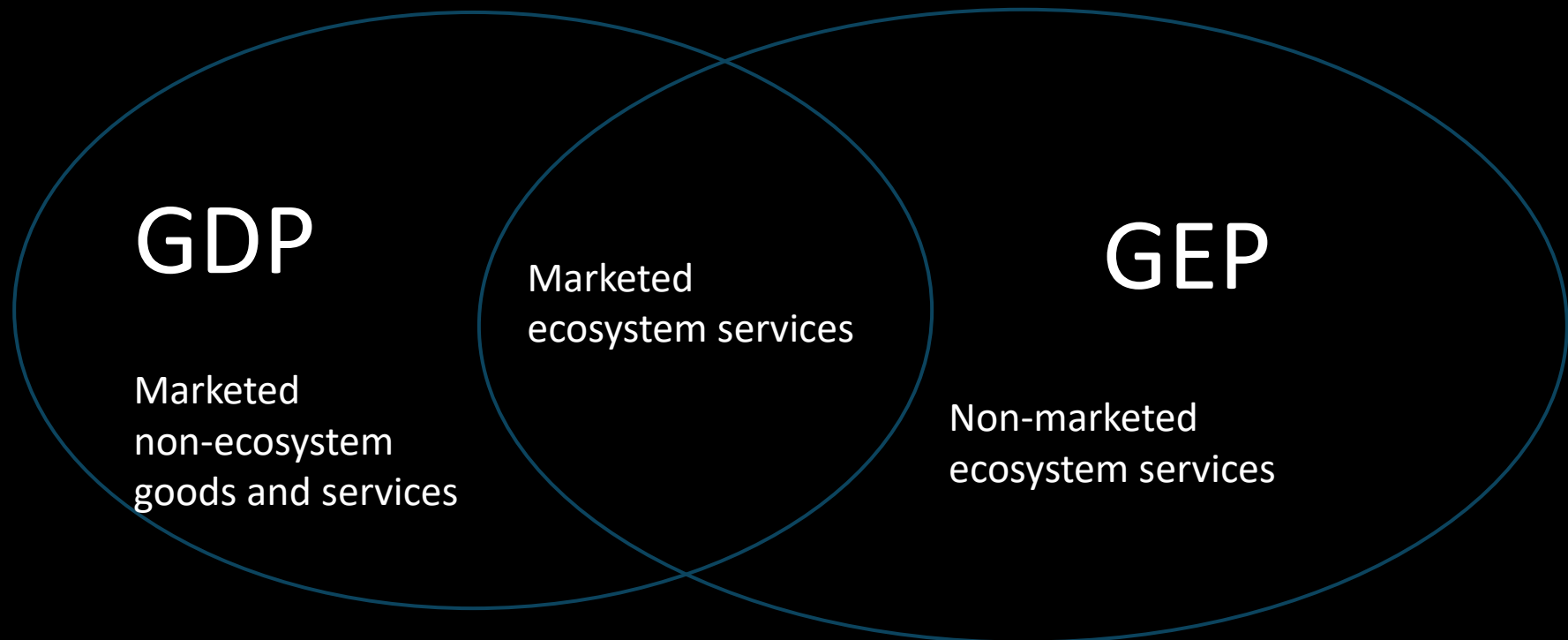
The need for better measures (“beyond GDP”)

- GDP provides clear and easily understood signal of market-based economic performance
- There is no current widely available summary measure of the contribution of nature to the economy or human well-being
- Without measures (and incentives) we risk further degradation of natural capital and the decline of valuable ecosystem services

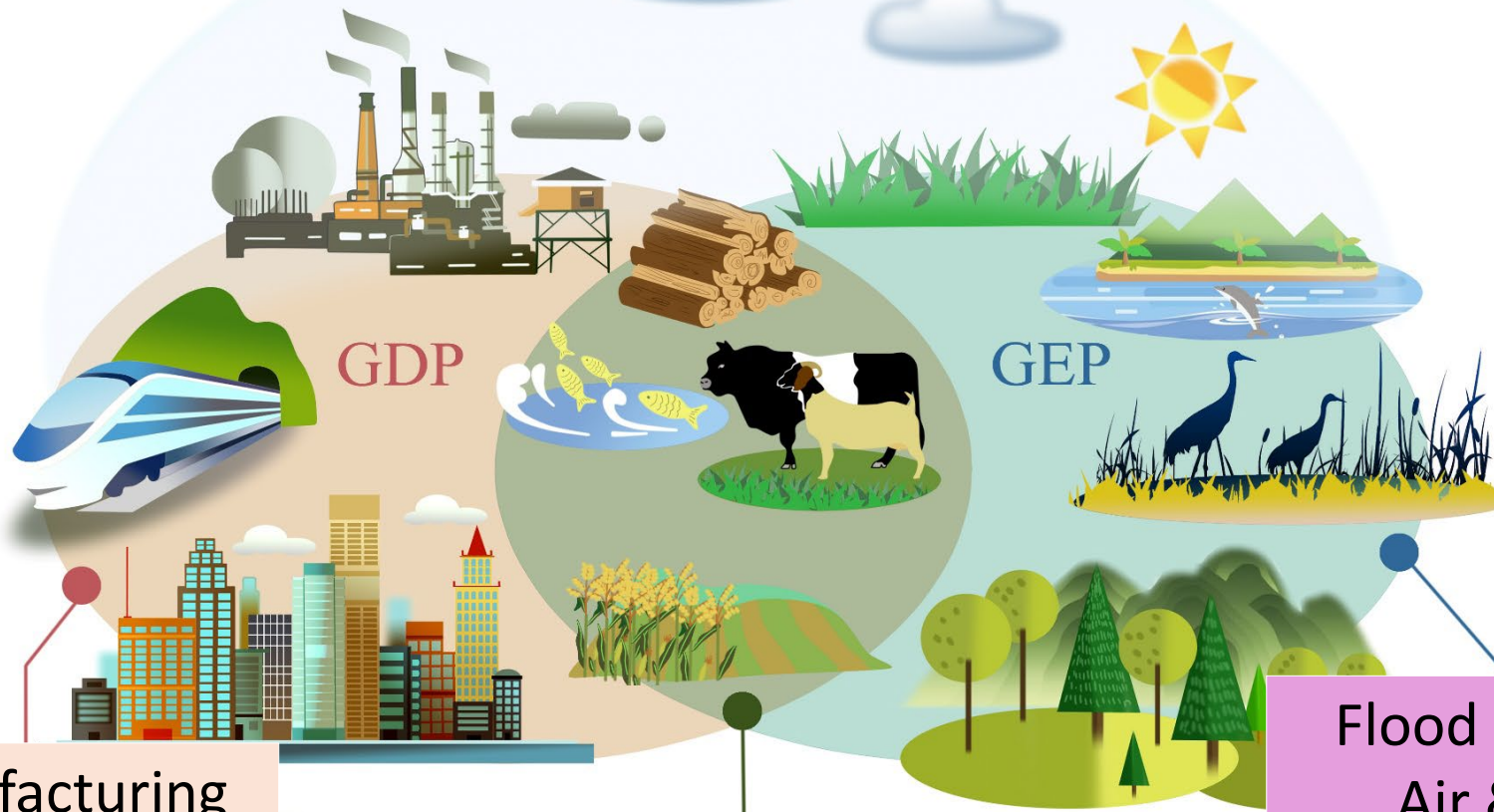


Gross Ecosystem Product (GEP)

- GDP: summary statistic that measures the flow of income from marketed goods and services in a region in an accounting period (e.g. measured annually for a country)
- GEP: summary statistic that measures the flow of monetary value from final market and non-market ecosystem goods and services in a region in an accounting period



GDP and GEP



Manufacturing
Construction
Transportation
Communication

Agriculture
Forestry
Tourism

Flood Protection
Air & Water
Purification
Crop Pollination
(Mental Health)

Measuring GEP

- Value of ecosystem service i :

$$V_i = \lambda_i P_i Q_i$$

λ_i = share of value attributed to nature for service i

= P_i is the per unit price (or shadow price determined by non-market valuation) of service i

= Q_i is the quantity of service i

Ecosystem services with available market value by country (FAO/SNA data)

- Some ecosystem services provide marketed commodities with recorded market value (P^*Q)
 - Agricultural crops
 - Livestock
 - Timber
 - Commercial fisheries
 - Energy (fossil fuels and renewables)
 - Mineral extraction
- For GEP, we then need the share attributable to nature: λ_i
- Input shares: deduct labor and human-made inputs to get input value from nature



Photo credits: Croplands Research Group (top)
National Geographic (bottom)

Non-market ecosystem services

- Virtually all regulatory and non-material services lack market price and quantity data
- Several approaches for calculating price and quantity
- Note: λ_i is equal to 1 in most cases



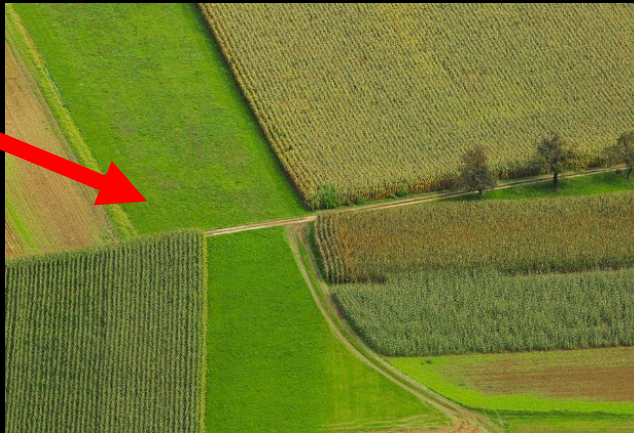
Photo credit: Steve Polasky

Calculating non-market prices and quantities

- Use Natural Capital Project InVEST models or other models to calculate biophysical quantity
 - Pollination (change in quantity/quality of crops due to pollination)
 - Air pollution (emissions/filtration to exposure to health outcomes)
 - Carbon (tons of carbon stored)
- Use literature values for price
 - Pollination: crop price
 - Air pollution (health): value of statistical life
 - Carbon storage: annual rental price based on the social cost of carbon



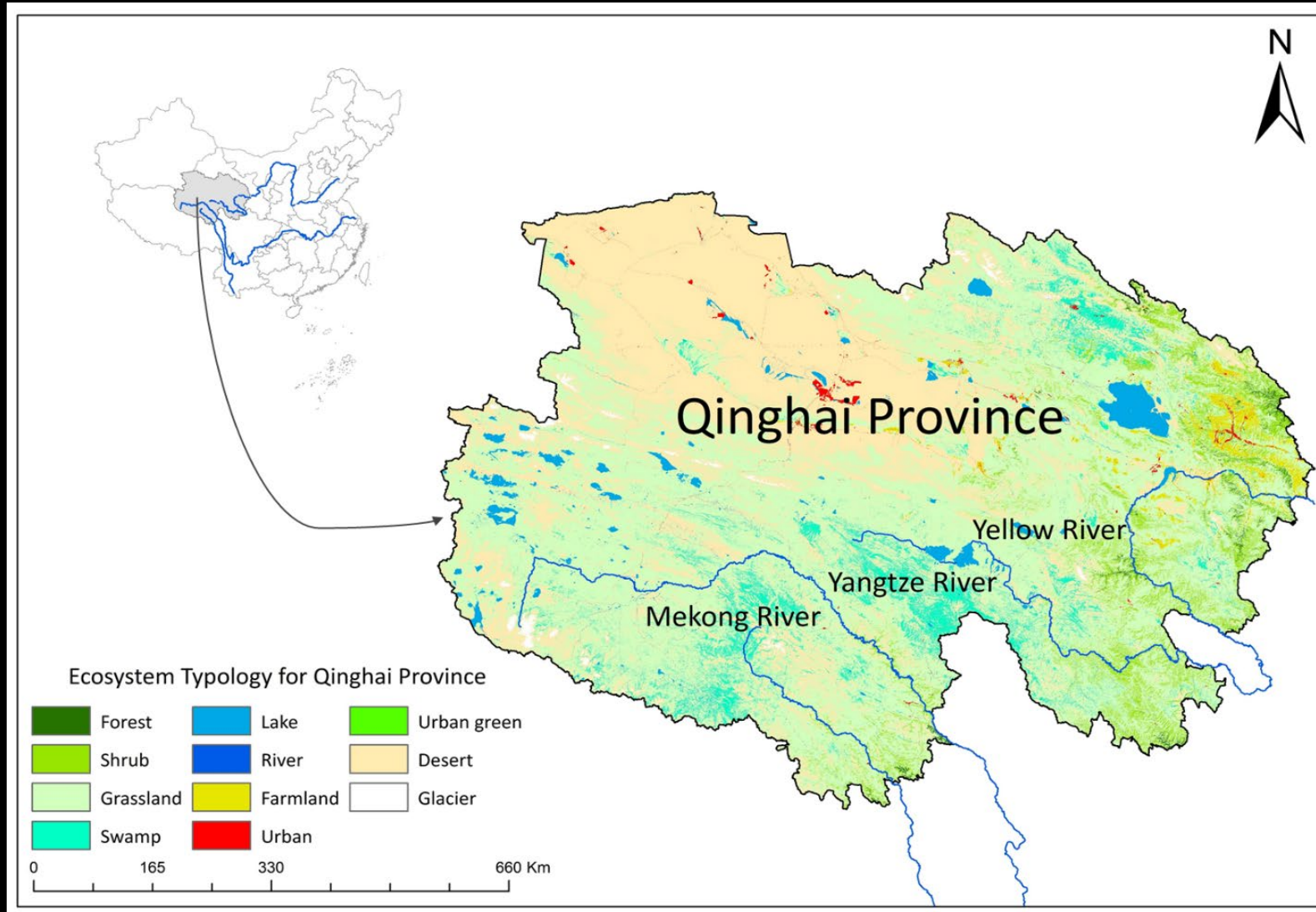
Photo credit: Pixabay



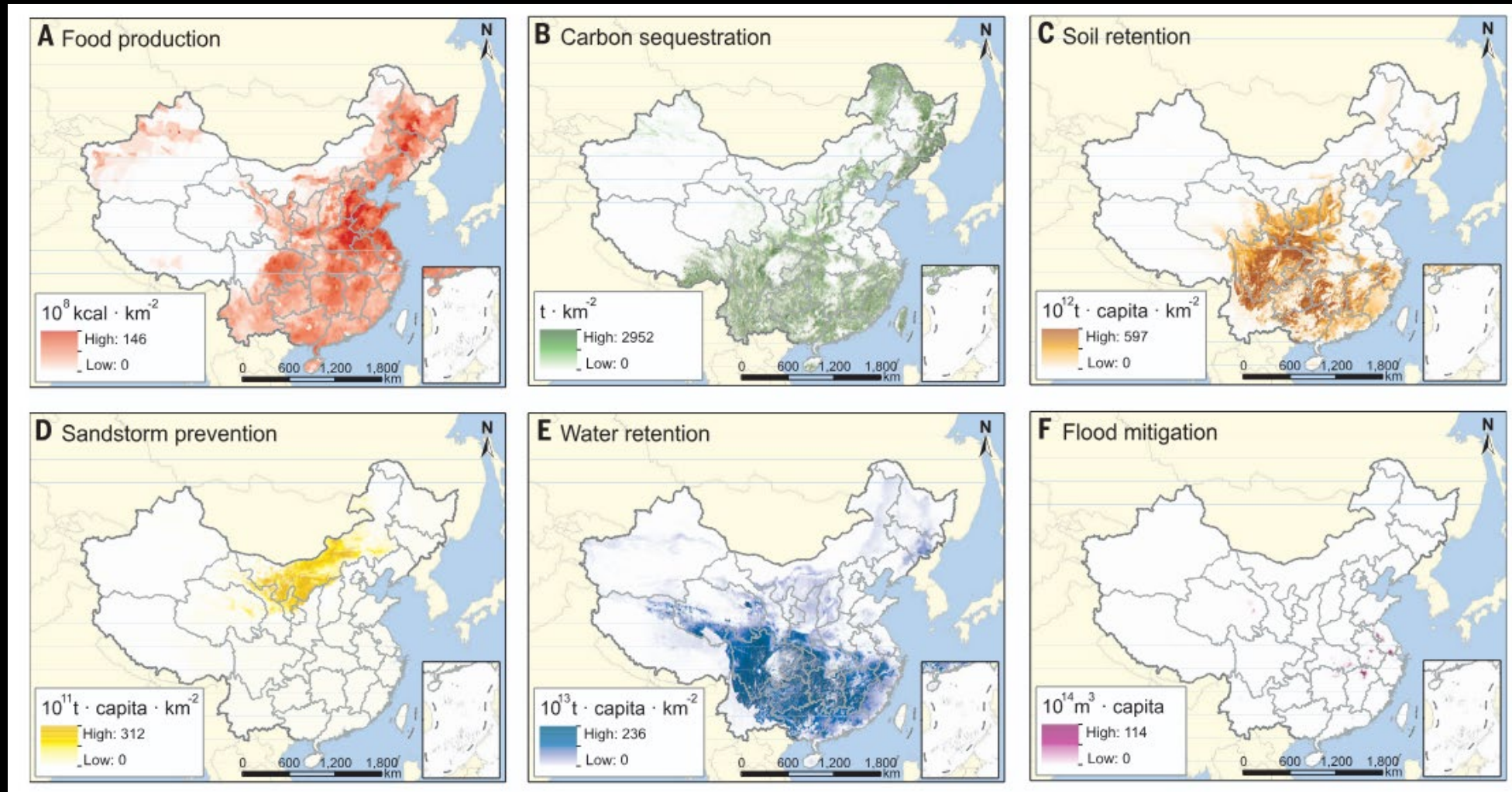
Aggregating services for GEP

- Aggregate the values of ecosystem goods and services into a single GEP metric
- Want complete coverage of all important ecosystem goods and services
- Avoid double-counting

Case study: Qinghai Province



Ecosystem service information for China

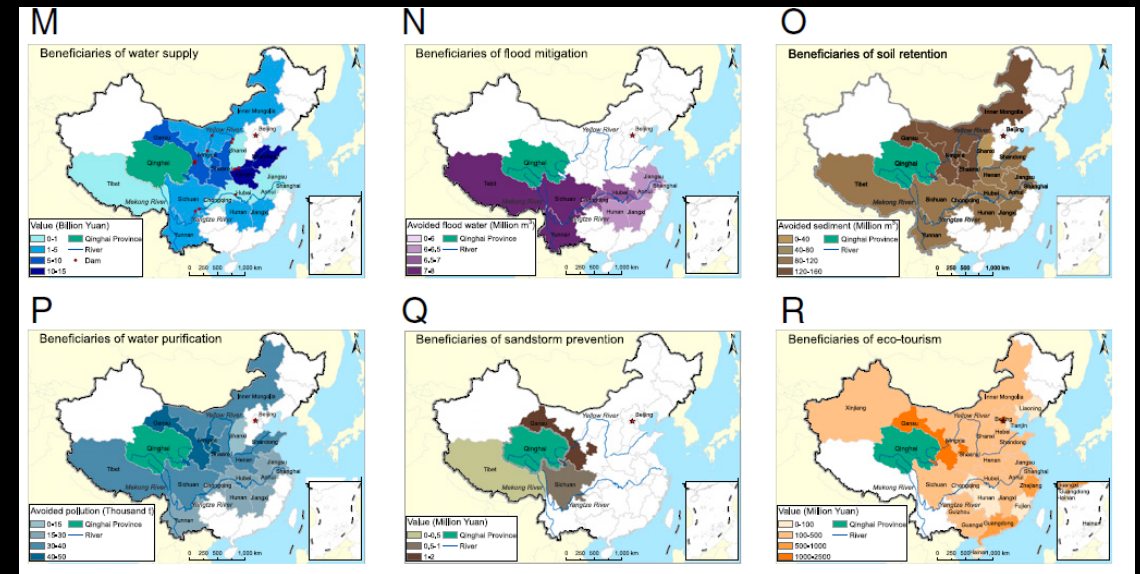
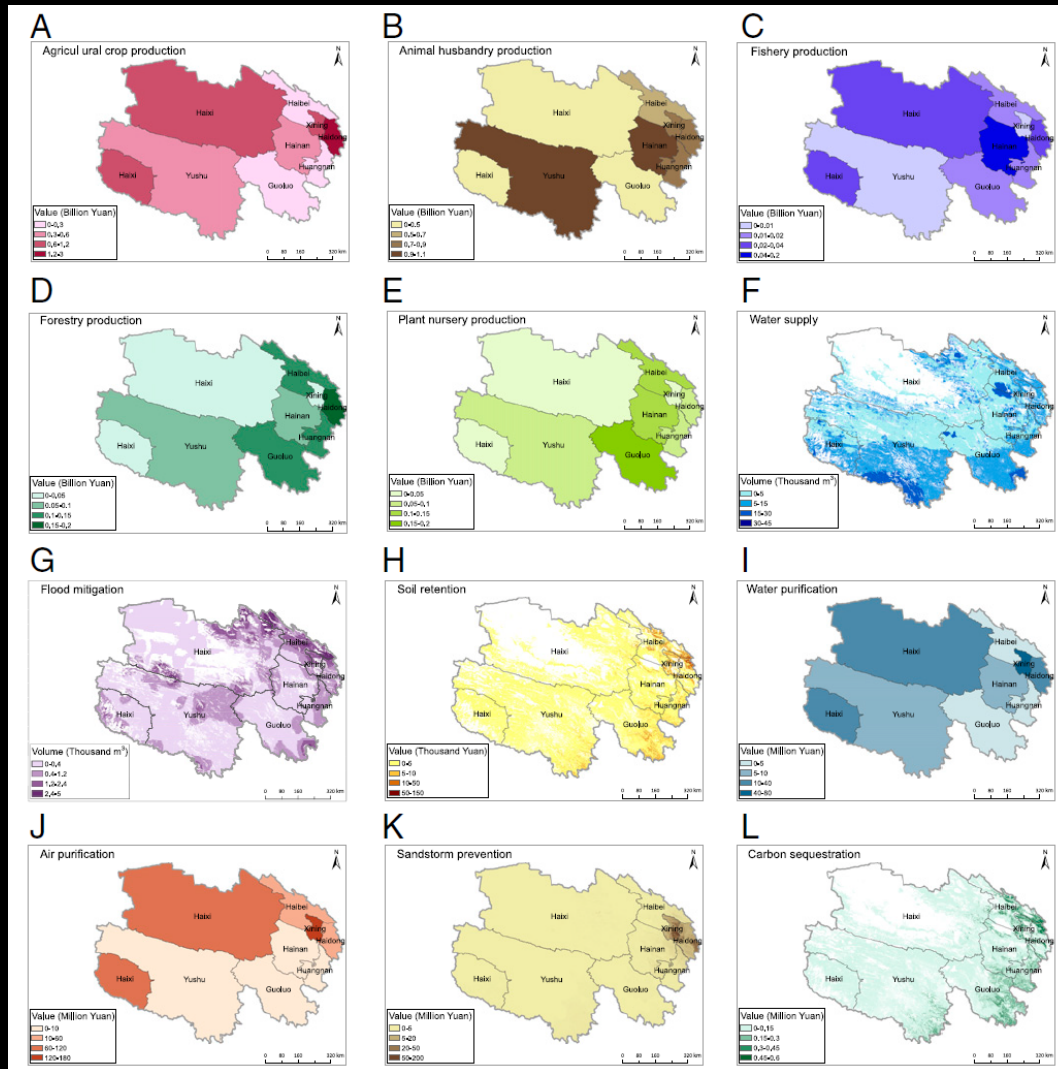


Example: GEP Accounting in Qinghai (2000 – 2015)

Types of services	Category of ecosystem services	Ecosystem service	2000			2015		
			Bio-physical quantity	Monetary value (Billion Yuan)	% of total value	Bio-physical quantity	Monetary value (Billion Yuan)	% of total value
Material services	Production of ecosystem goods	Agricultural crop production (x10 ³ t)	1652.1	1.0	1.2	3091.2	5.6	3.0
		Animal husbandry production (x10 ³ t)	458.7	1.1	1.4	724	5.8	3.1
		Fishery production (x10 ³ t)	1.2	0.01	0.01	10.6	0.3	0.1
		Forestry production (x10 ³ m ³)	1800	0.2	0.2	825	0.7	0.4
		Plant nursery production (x10 ⁹)	0.3	0.2	0.2	11	0.7	0.4
		Total		2.5	3.0		13.1	7.1
	Water supply	Water use in downstream agricultural irrigation (x10 ⁹ m ³)		11.8	14.5		15.0	8.1
		Water use in households (x10 ⁹ m ³)		5.3	6.5		13.8	7.4
		Water use in industry (x10 ⁹ m ³)		19.4	23.8		29.2	15.8
		Hydropower production (x10 ⁹ kwh)	21.3	11.3	13.9	92	48.8	26.3
		Total		47.8	58.7		106.7	57.6
Regulating services	Flood mitigation	Flood mitigation (x10 ⁹ m ³)	0.07	0.02	0.03	0.07	0.03	0.02
	Soil retention and non-point pollution prevention	Retained soil (x10 ⁹ t)	0.4	4.8	5.9	0.4	7.0	3.8
		Retained N (x10 ³ t)	9.8	0.01	0.01	10	0.02	0.01
		Retained P (x10 ³ t)	0.7	0.002	0.002	0.7	0.002	0.001
	Water purification (wetland)	COD purification (x10 ³ t)	33.2	0.02	0.03	104.3	0.1	0.1
		NH-N purification (x10 ³ t)	3.5	0.00	0.004	10	0.02	0.01
		TP purification (x10 ³ t)	-	-	-	0.9	0.003	0.001
	Air purification	SO ₂ purification (x10 ³ t)	32.0	0.02	0.02	150.8	0.2	0.1
		NO _x purification (x10 ³ t)	-	-	-	117.9	0.1	0.1
		Dust purification (x10 ³ t)	105.5	0.02	0.02	246	0.04	0.02
	Sandstorm prevention	Sand retention (x10 ⁹ t)	0.3	21.4	26.2	0.5	31.7	17.1
Non-material services	Carbon sequestration	Carbon sequestration (x10 ⁹ t)	0.01	2.0	2.4	0.02	4.7	2.5
		Total		28.3	34.7		43.9	23.7
	Eco-tourism	Tourists (x10 ⁶ persons)	3.2	3.0	3.7	23.2	21.6	11.7
Grand Total				81.5	100.0		185.4	100.0

Source: Ouyang et al. 2020

Generation of ecosystem services (A – L) and beneficiaries of services (M – R)



GEP results for all
countries for 2019
("Global GEP")



Ecosystem services included: biotic and abiotic

Regulating ecosystem services	Material ecosystem services	Non-material ecosystem services
Global climate regulation (terrestrial, coastal, and marine carbon storage)	Agricultural crop provision (commercial and subsistence)	Recreation and tourism
Regional climate regulation (rainfall pattern regulation)	Livestock provision	Physical health benefits from nature exposure (hypertension reduction)
Local climate regulation (urban cooling)	Fish provision (commercial and subsistence)	Mental health benefits from nature exposure
Air filtration	Timber provision	
Erosion control	Fuelwood	
Landslide mitigation	Non-timber forest products provision	
Storm mitigation (sand and dust control)	Water supply	
Water filtration (nutrient retention)	Solar energy provision	
Groundwater recharge	Wind energy provision	
Coastal protection	Geothermal energy provision	
River flood mitigation	Hydropower provision	
Pollination	Fossil fuel provision (oil and natural gas)	
Pest control	Fossil fuel provision (coal)	
	Mineral extraction	

Results

- Report results for three services (two regulating services and one material service)
 - Air filtration
 - Carbon storage
 - Hydropower production
- Other services still in the process of “sanity checking”
 - Reviewing all methods and data
 - Cross checking with other studies where possible
 - Expert review

Results for selected countries (top 5 in one of these services)

Country	Annual rental value of carbon storage (million USD 2019)	Air filtration (million USD 2019)	Hydropower production (million USD 2019)
Brazil	812,960	384	51,281
Canada	346,691	107	33,154
China	176,974	3,268	81,119
Democratic Republic of Congo	263,330	11	-
France	24,547	1,029	4,148
Germany	18,413	2,012	3,757
India	64,833	1,007	6,430
Japan	21,313	228	12,767
Russia	670,663	412	-
United States	352,743	1,418	20,785
Global total	5,365,469	17,809	287,732

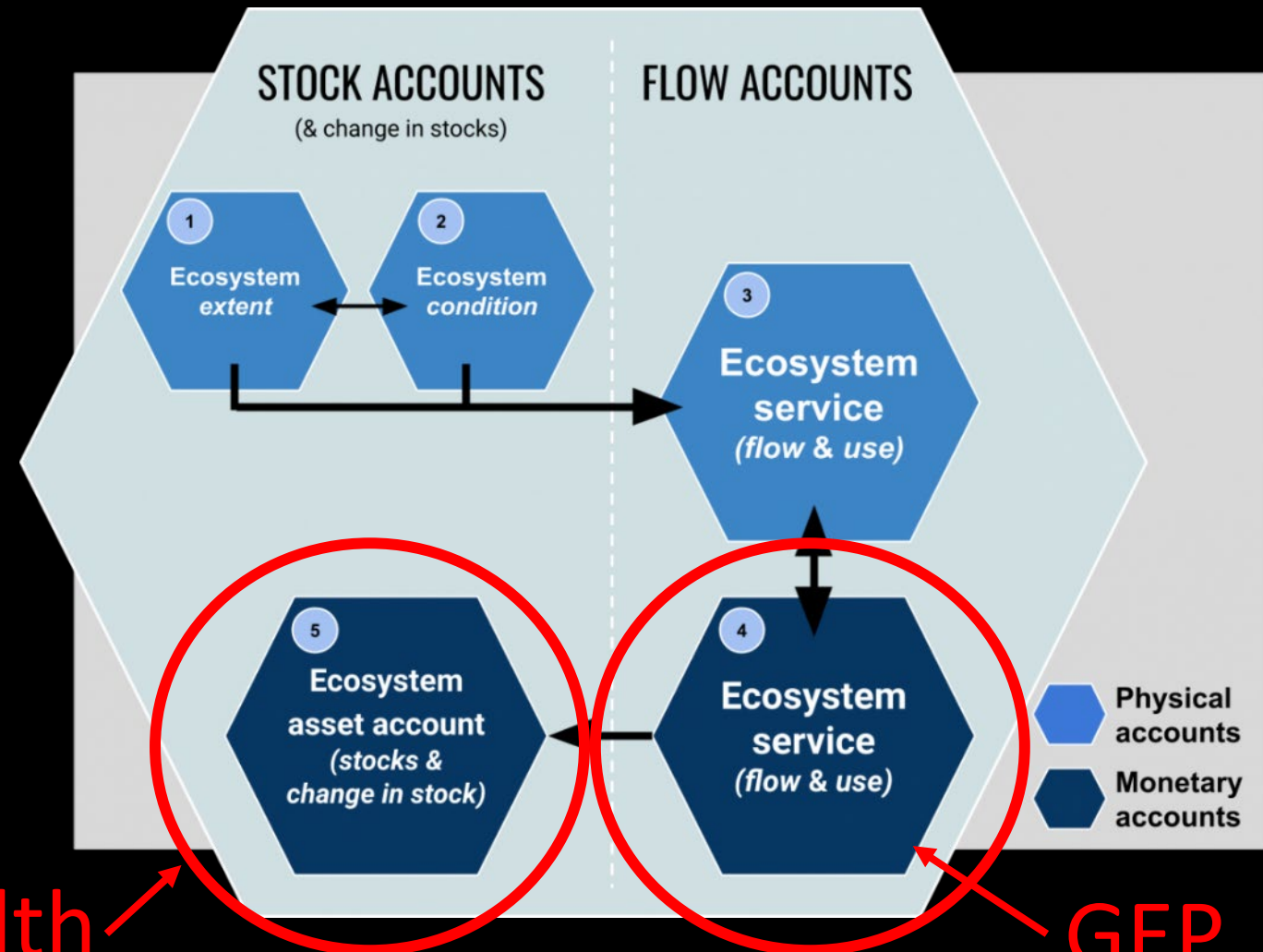
Discussion

- Goal: development of standardized methods and use of globally available data for GEP accounting
 - Demonstrate that it is possible to calculate GEP with existing data and methods
- Emphasize that this is a first step to measuring GEP – not the last word
 - GDP and System of National Accounts took decades to mature – and is still being refined
- Stimulate the research community
 - Highlight knowledge gaps
 - Point out needs for additional data collection
 - Point out needs for additional methods development



Photo credit: Steve Polasky

Relationship of GEP and SEEA EA (2021)



Inclusive wealth

GEP

Final thought

- The Great Depression in the 1930s led society to realize the urgent need for better macroeconomic performance metrics, such as GDP, to help guide economic policy
- The current “Great Degradation” in natural capital should lead society to realize the urgent need for better metrics of ecosystem services and natural capital, such as GEP, to help guide sustainable development

