Gross Ecosystem Product (GEP)

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Julian suggestions

On substance: (80% of presentation time)

- What did you do?
- Which services did you value?
- Highlight of results (maps/ tables)

On process: (minimum, up to 20% of presentation time)

- What were the partners you worked with?
- What went well and what didn’t?
- What were the challenges identified?
- Were the accounts already used?

Outline

- Gross Ecosystem Product (GEP)
- GEP accounting framework
- GEP pilot accounting
- GEP applications
- Findings and challenges

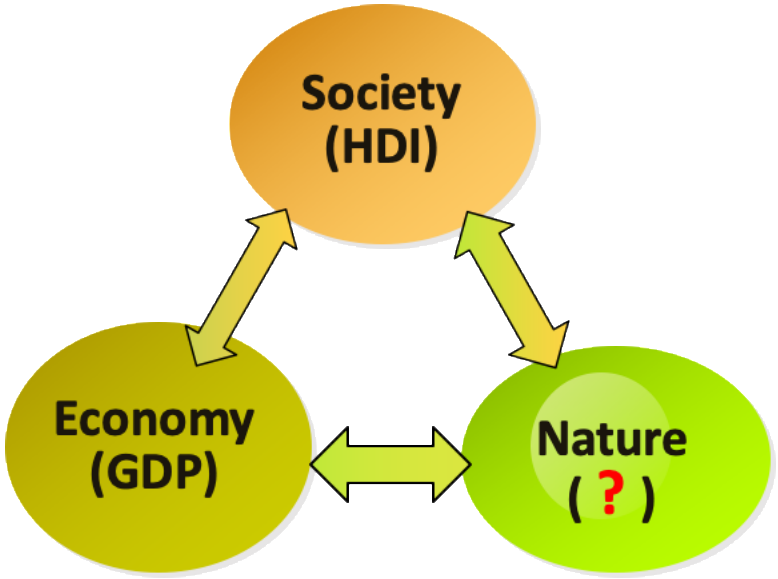
- What is GEP?
- How to Measure GEP
- How to Apply GEP

Gross Ecosystem Product

(What is GEP?)

Need a metrics to measure nature contribution to people

- Economy: **GDP (Gross Domestic Product)** is widely used to measure economic system performance.
- Society: **HDI (Human Development Index)** is used to measure social development status based on health, education, and income.
- Nature: currently we do not have a widely used indictor to measure its contribution to human wellbeing.



In order to advance an ecological civilization in China

- President Xi put forward the vision "**Clear water and green mountains are gold and silver mountains"**, to give prominence nature's value for people
- This involves:
  - ✓ Integration of **ecological benefits** into criteria for performance evaluation of local governments
  - ✓ Establishment of **eco-compensation policy based on ecosystem services**
  - ✓ Establishment of a **natural capital accounting system.**

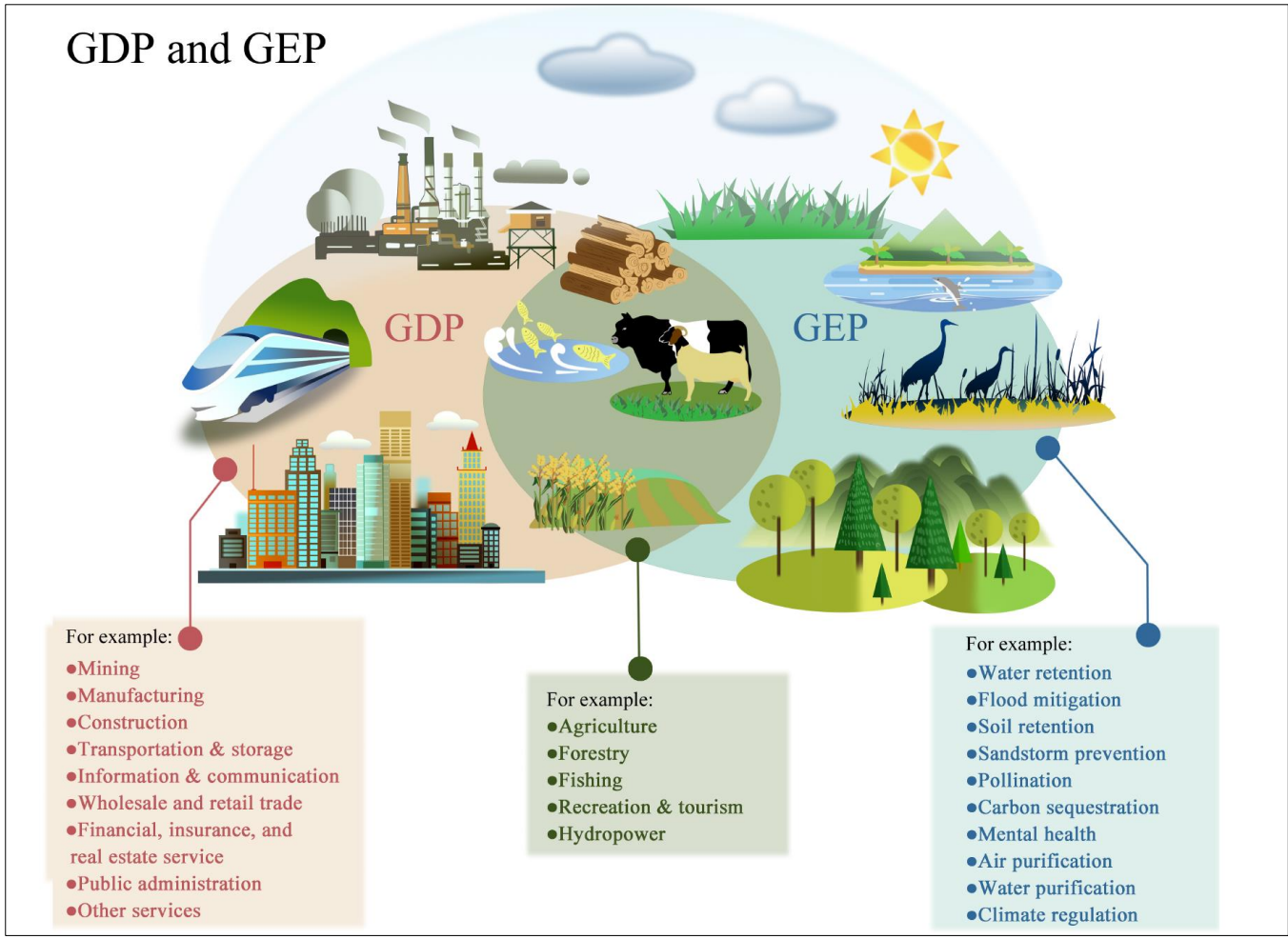
GEP

Gross Ecosystem Product, GEP

- GEP is the aggregated value of final ecosystem goods and services supplied annually to people in given region, such as a country, a province, or a county.

Ecosystem asset, EA

- EA is a natural asset providing ecosystem services to people, including forest, grassland, wetland, marine, and other natural and managed ecosystems.



Accounting framework of GEP

(How to Measure GEP)

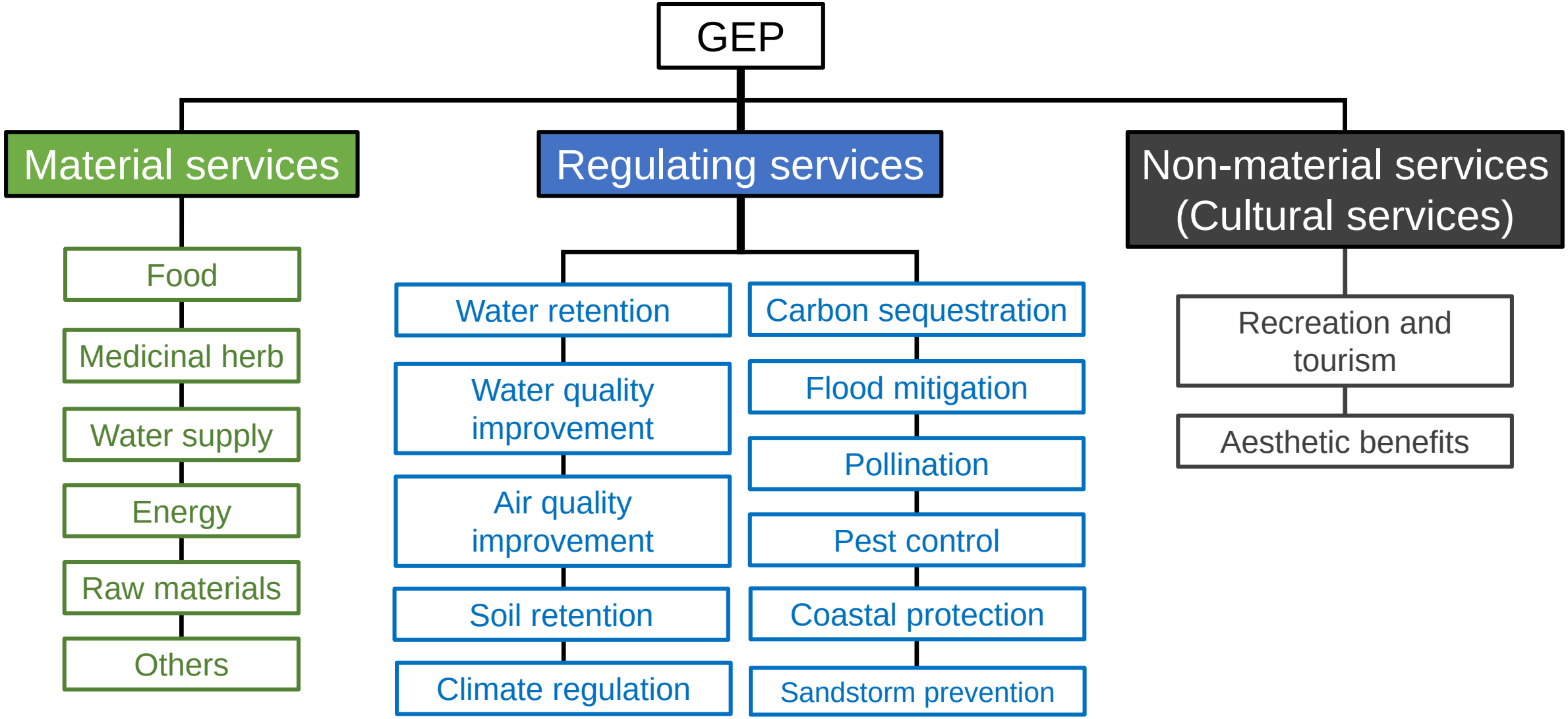
GEP accounting framework

Criteria of GEP accounting

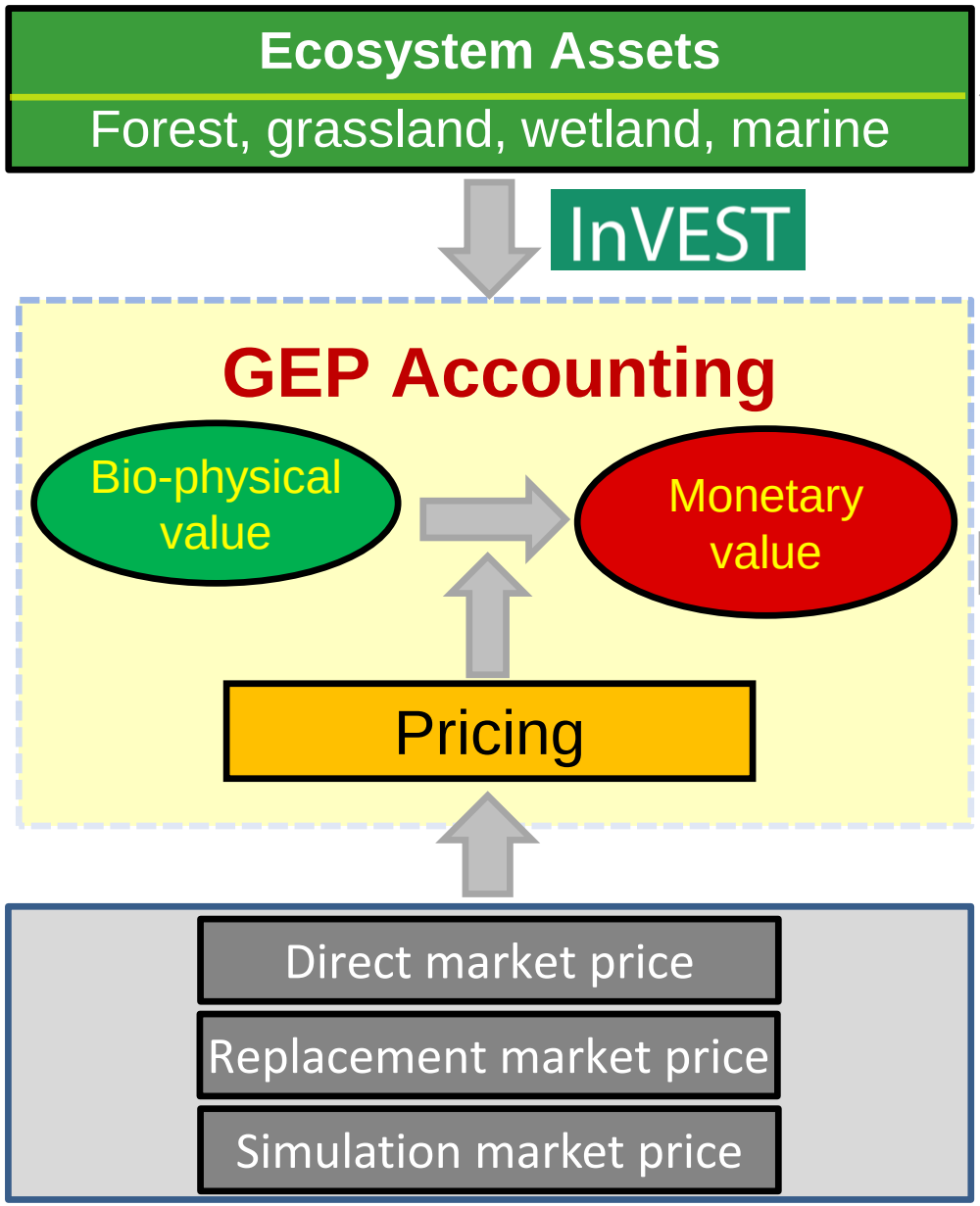
- GEP is a measurement of the aggregate monetary value of ecosystem-related goods and services in a given region in an accounting period
- Measure use value of ecosystem services
  - ✓ Direct use value: e.g., food, bio-energy, water resources
  - ✓ Indirect use value: e.g., water retention, soil retention, pollutant purification, climate regulation
- Measure value of final eco-services
  - ✓ Material services (ecosystem goods), regulating services, and non-material services
- First, measure bio-physical value (quantity)
  - ✓ E.g., amount of food production, amount of water retention, amount of soil retention
- Second, measure monetary value (value added per unit x quantity)
  - ✓ The economic value of ecosystem services

GEP accounting framework

Ecosystem services in GEP accounting



GEP accounting framework



a) **Accounting of bio-physical values of ecosystem goods and services**

b) **Pricing of ecosystem goods or services**

c) **Accounting of economic values of ecosystem goods and services**

$$GEP = EMV + ERV + ECV$$

$$GEP = \sum_{i=1}^{n} EM_i \times P_i + \sum_{j=1}^{m} ER_j \times P_j + \sum_{k=1}^{l} EC_k \times P_k$$

GEP accounting methods

Services	Indicators	Quantity indicators	Quantitative valuation methods	Value indicators	Value valuation methods
Material services	Food	Production of food	Statistical data	Value of food	Market price method
	Medicinal herb	Production of medical herb		Value of medical herb	
	Water supply	Amount of water use		Value of water consumption	
	Energy	Production of energy		Value of energy	
	Raw materials	Production of raw materials		Value of raw materials	
	Others	e.g., production of ornamental resources		Value of ornamental resources	
Regulating services	Pollination	Production of increased yields	Pollination model	Value of increased crop	
	Water retention	Amount of water retention	Water Balance Equation	Value of water retention	Replacement market method
	Soil retention	Amount of soil retention	RUSLE	Value of sediment reduction	
	Flood mitigation	Lake: adjustable storage capacity	Hydrologic data	Value of flood mitigation	
		Reservoir: flood control storage	Monitoring data		
		Swamp: stagnant water			
	Sandstorm prevention	Amount of sand-fixation	REWQ	Value of desertification reduction	
	Carbon sequestration	Amount of carbon sequestration	Mass balance method	Value of carbon dioxide sequestration	
	Air quality improvement	Amount of air pollution absorption	Model of plants purification	Value of air pollution treatment	
	Water quality improvement	Amount of point pollution reduction	Model of water purification	Value of point pollution treatment	
		Amount of non-point pollution reduction		Value of non-point pollution treatment	
	Climate regulation	Energy consumption of plant transpiration	Model of transpiration and evaporation	Value of plant transpiration	
		Energy consumption of water surface evaporation		Value of water surface evaporation	
	Pest control	Area of pest and disease occurrence	Analogy method	Value of biological control	
	Coastal zone conservation	Length of coastal zone	Monitoring data	Value of coastal zone conservation	
Non-material services	Recreation and tourism	Number of tourists	Travel cost method	Value of landscape recreation	Travel cost method
	Aesthetics	Area of beneficial lands and buildings	Statistic data	Value of lands and buildings premium	Hedonic price method

GEP accounting methods

✧Production of ecosystem goods

✓ Biophysical quantity

$$Q_i = Q_{yi} \times F_{ni}$$

- Q_i is the biophysical quantity of ecosystem goods i; Q_{yi} is the yield of ecosystem goods i from economic accounting systems; F_{ni} is the portion of input from nature of ecosystem goods i.

✓ Monetary value

$$V_i = V_{yi} \times F_{ni}$$

- V_i is the monetary value of ecosystem goods i; V_{yi} is the value of ecosystem goods i from economic accounting systems; F_{ni} is the portion of input from nature of ecosystem goods i.

✧Water supply

✓ Biophysical quantity

$$Q_I = Q_{LI} + \sum_{i=1}^{n} F_{iU} W_{iI}$$

$$Q_D = Q_{LD} + \sum_{i=1}^{n} F_{iU} W_{iD}$$

$$Q_{HP} = Q_{LHP} + \sum_{j=1}^{m} F_{jU}\, E_j$$

$$Q_{DA} = \sum_{i=1}^{n} F_{iU} W_{iA}$$

- Q_I, Q_D, and Q_{HP} is the quantity of water use in industry, domestic, and hydropower production in local area and downstream; Q_{DA} is the quantity of water use in downstream.

✓ Monetary value

$$V_D = Q_{LD} P_{LD} + \sum_{i=1}^{n} Q_{iD}\, P_{iD}$$

$$V_D = Q_{LD} P_{LD} + \sum_{i=1}^{n} Q_{iD}\, P_{iD}$$

$$\mathrm{V_{HP}} = (Q_{LHP} + Q_{DHP}) \times P_E$$

$$V_{\mathrm{A}} = \sum_{i=1}^{N} Q_{iA} \times E_{iI} \times E_{CU} \times P_A \times F_A$$

- V_I, V_D, and V_{HP} is the value of water use in industry, domestic, and hydropower production in local area and downstream; V_A is the value of crop downstream irrigated by water from upstream.

GEP accounting methods

✧Water retention

✓ Biophysical quantity

$$\mathrm{Q_{wr}} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{A_i} \times (\mathrm{P_i} - \mathrm{R_i} - \mathrm{ET_i})$$

- Q_{wr} is the biophysical quantity of water retention; $\mathrm{A_i}$ is the area of ecosystem i; $\mathrm{P_i}$ is precipitation of ecosystem i; R_i is storm runoff of ecosystem i; ET_i is evapotranspiration of ecosystem i.

✓ Monetary value

$$V_{wr}=\mathrm{Q}_{wr} \times c$$

- V_{wr} is the value of water retention service; $\mathrm{Q_{wr}}$ is the biophysical quantity of water retention; c is the average cost of reservoir construction.

✧Soil retention

✓ Biophysical quantity (RUSLE model)

$$Q_{sr} = R \times K \times LS \times (1 - C \times P)$$

$$Q_{rN}=Q_{sr} \times c_N \times t_N \times d_N$$

$$Q_{rP}=Q_{sr} \times c_P \times t_P \times d_P$$

- Q_{sr} is the soil retention capacity; Q_{rN} and Q_{rP} are the quantity of Nitrogen and Phosphorus in sediment.

✓ Monetary value

$$V_{sr}=V_{sd}+V_{rN}+V_{rP}$$

$$V_{sd}=\lambda \times (Q_{sr}/\rho) \times c$$

$$V_{rN}=Q_{rN} \times p_{TN}$$

$$V_{\mathrm{r}P}=Q_{rP} \times p_{TP}$$

- V_{sr} is the monetary value of soil retention; V_{sd}, V_{rN}, and V_{rP} are the reduced cost of dredging, non-point source pollution treatment of N and P.

GEP accounting methods

✧Flood mitigation

✓ Biophysical quantity

$$Q_{\mathrm{fm}} = Q_{\mathrm{vfm}} + Q_{\mathrm{wfm}} + Q_{\mathrm{lfm}} + Q_{\mathrm{rfm}}$$

$$\mathrm{Q_{vfm}} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{A_i} \times (\mathrm{P_i} - \mathrm{R_i} - \mathrm{ET_i}) \times 10^{-3}$$

$$\mathrm{Q_{wfm}} = A_s \times H_s$$

East: $Q_{\mathrm{lfm}} = e^{4.924} \times A^{1.128} \times 3.19$

Northwest: $Q_{\mathrm{lfm}} = e^{5.653} \times A^{0.680} \times 0.26$

Southwest: $Q_{\mathrm{lfm}} = e^{4.904} \times A^{0.927} \times 0.36$

Qinghai-Tibet Plateau: $Q_{\mathrm{lfm}} = e^{6.636} \times A^{0.678} \times 0.14$

Northeast: $Q_{\mathrm{lfm}} = e^{5.808} \times A^{0.866} \times 0.98$

$$\mathrm{Q_{rfm}} = R_t \times 0.35$$

- Q_{fm} is the biophysical quantity of flood mitigation; Q_{vfm}, Q_{wfm}, Q_{lfm}, and Q_{rfm} are flood storage provided by vegetation, wetlands, lake, and reservoir.

✓ Monetary value

$$V_{fm} = \mathrm{Q}_{fm} \times c$$

- V_{fm} is the value of flood mitigation service; c is the average cost of reservoir construction.

✧Sandstorm prevention

✓ Biophysical quantity (RWEQ model)

$$Q_{sp} = 0.1699 \times (WF \times EF \times SCF \times K')^{1.3711} \times (1 - C^{1.3711})$$

- Q_{sp} is the amount of sand fixation as the difference between wind erosion without vegetation cover and wind erosion under the current land cover.

✓ Monetary value

$$V_{sp} = V_p - V_a = M \times C \times (P_p n_p - P_a n_a)$$

- V_{sp} is the monetary value of sandstorm prevention; V_p the health costs of potential exposure to sand assuming there is no vegetation; V_a is the health costs of actual exposure to sand.

GEP accounting methods

✧Carbon sequestration

✓ Biophysical quantity

$$Q_{cs} = Q_{fcs} + Q_{gcs} + Q_{wcs}$$

$$Q_{fcs} = R_{fcs} \times S_f$$

$$Q_{gcs} = R_{gcs} \times S_g$$

$$Q_{wcs} = \sum_{i=1}^{n} R_{iwcs} \times S_{iw}$$

- Q_{cs} is the biophysical quantity of carbon sequestration; Q_{fcs}, Q_{gcs}, and Q_{wcs} is the quantity of carbon sequestration by forest, shrub and grassland.

✓ Monetary value

$$V_{cs} = Q_{cs} \times C_a$$

$$V_{op} = Q_{op} \times C_{op}$$

- V_{cs} is the value of carbon sequestration; C_a is the afforestation cost;

✧Climate regulation

✓ Biophysical quantity

$$Q_{cr} = Q_{pt} + Q_{we}$$

$$Q_{pt} = \sum_{i}^{3} EPP_i \times S_i \times D \times 10^6/(3600 * r)$$

$$Q_{we} = E_w \times q \times 10^3/(3600) + E_w \times y$$

- Q_{cr} is the total energy consumed by ecosystem transpiration and evaporation; Q_{pt} is the energy consumed by transpiration of plants; Q_{we} is energy consumed by evaporation of wetlands.

✓ Monetary value

$$V_{cr} = Q_{cr} \times P_e$$

- V_{cr} is the monetary value of climate regulation; P_e is the price of electricity.

GEP accounting methods

✧Air quality improvement

✓ Biophysical quantity

$$QA_{jl} = Min\left[A_{jl}, \sum_{i=1}^{I} A_{il}\, QA_{ij}\right]$$

- QA_{jl} is the amount of air purification for pollution j; A_{jl} is the total emission amount of pollution j; QA_{ij} is the purification capacity of ecosystem i for pollution j.

✓ Monetary value

$$V_{ap} = \sum_{j}^{J} QA_{jl} \times C_j$$

- V_{ap} is the value of air purification service; C_j is treatment cost of pollution j.

✧Water quality improvement

✓ Biophysical quantity

$$QW_{jl} = Min\left[W_{jl}, \sum_{i=1}^{I} A_{il}\, QW_{ij}\right]$$

- QW_{jl} is the amount of water purification for pollution j; W_{jl} is the total emission amount of pollution j; QW_{ij} is the purification capacity of ecosystem i for pollution j.

✓ Monetary value

$$V_{wp} = \sum_{j}^{J} QW_{jl} \times C_j$$

- V_{ap} is the value of water purification service; C_j is treatment cost of pollution j.

GEP accounting methods

✧Pollination

✓ Biophysical quantity

$$Q_{ps} = \sum_i [Y_i \times D_i]$$

- Q_{ps} is the increased yield of crop from pollination; Y_i is the yield of crop I; D_i is the insect pollination dependence of crop i.

✓ Monetary value

$$V_{ps} = \sum_i [Q_{ps} \times P_i]$$

- V_{ps} is the value of pollination service; Q_{ps} is the increased yield of crop from pollination; P_i is the price of crop i.

✧Pest control

✓ Biophysical quantity

$$Q_{PC} = S_{fpc} + S_{gpc}$$

- Q_{pc} is the area of ecosystem where pests and diseases heal themselves; S_{fpc} is the area of natural forest where pests and diseases heal themselves; S_{gpc} is the area of natural grasslands where pests and diseases heal themselves.

✓ Monetary value

$$V_{pc} = S_{fpc} \times C_{fpc} + S_{gpc} \times C_{gpc}$$

- V_{pc} is the monetary value of pest control; C_{fpc} is the cost of artificial pest control per unit area of forest; C_{gpc} is the cost of artificial pest control per unit area of grassland.

GEP accounting methods

✧Coastal zone conservation

✓ Biophysical quantity

$$Q_{cc} = \sum_{n}^{i=1} D_{cli}$$

- Q_{cc} is the biophysical quantity of coastal zone conservation; D_{cli} is length of coastal zone protected by ecosystem i.

✓ Monetary value

$$V_{cc} = Q_{cc} \times C_{cc}$$

- V_{cc} is the value of coastal zone conservation service; C_{cc} is the construction cost of coastal zone protective engineering per unit length.

GEP accounting methods

✧Recreation and tourism

✓ Biophysical quantity

$$\mathrm{Q_{rt}} = \mathrm{N_t}$$

- $\mathrm{Q_{rt}}$ is the biophysical quantity of recreation and tourism; $\mathrm{N_t}$ is the number of tourists.

✓ Monetary value

$$V_{rt}=V_{trc}+V_{tic}$$

- V_{rt} is the value of recreation and tourism service; $\mathrm{V_{trc}}$ is travel cost of tourists; $\mathrm{V_{tic}}$ is time cost of tourists.

The methods and models can be referred to Ouyang ZY, Song CS, Zheng H, Polasky S et.al. Using Gross Ecosystem Product (GEP) to Value Nature in Decision-Making *(Supporting Information)*. *PNAS.* 2020, 117(25): 14593-14601.

✧Aesthetics

✓ Biophysical quantity

$$Q_{\mathrm{ae}}=\sum_{i=1}^{n} A_i$$

- Q_{ae} is the biophysical quantity of aesthetics service; A_i is the area of beneficial lands and buildings in region i.

✓ Monetary value

$$V_{\mathrm{ae}}=\sum_{i=1}^{n} A_i \times P_{\mathrm{i}}$$

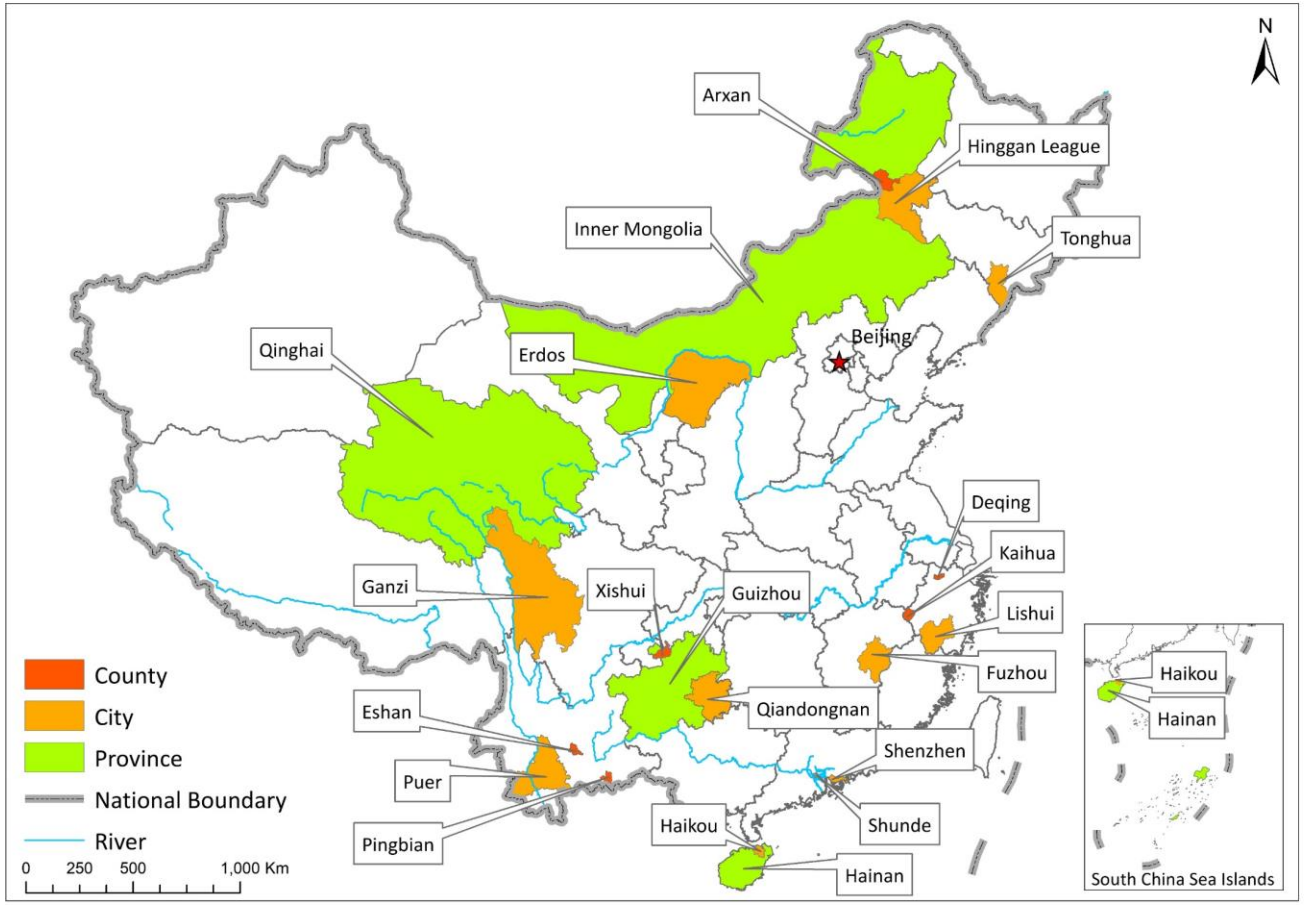
- V_{ae} is the monetary value of aesthetics service; P_{i} is the premium price of per unit lands and buildings in region i.

GEP pilot accounting in China

GEP pilot accounting

Pilot GEP accounting in China

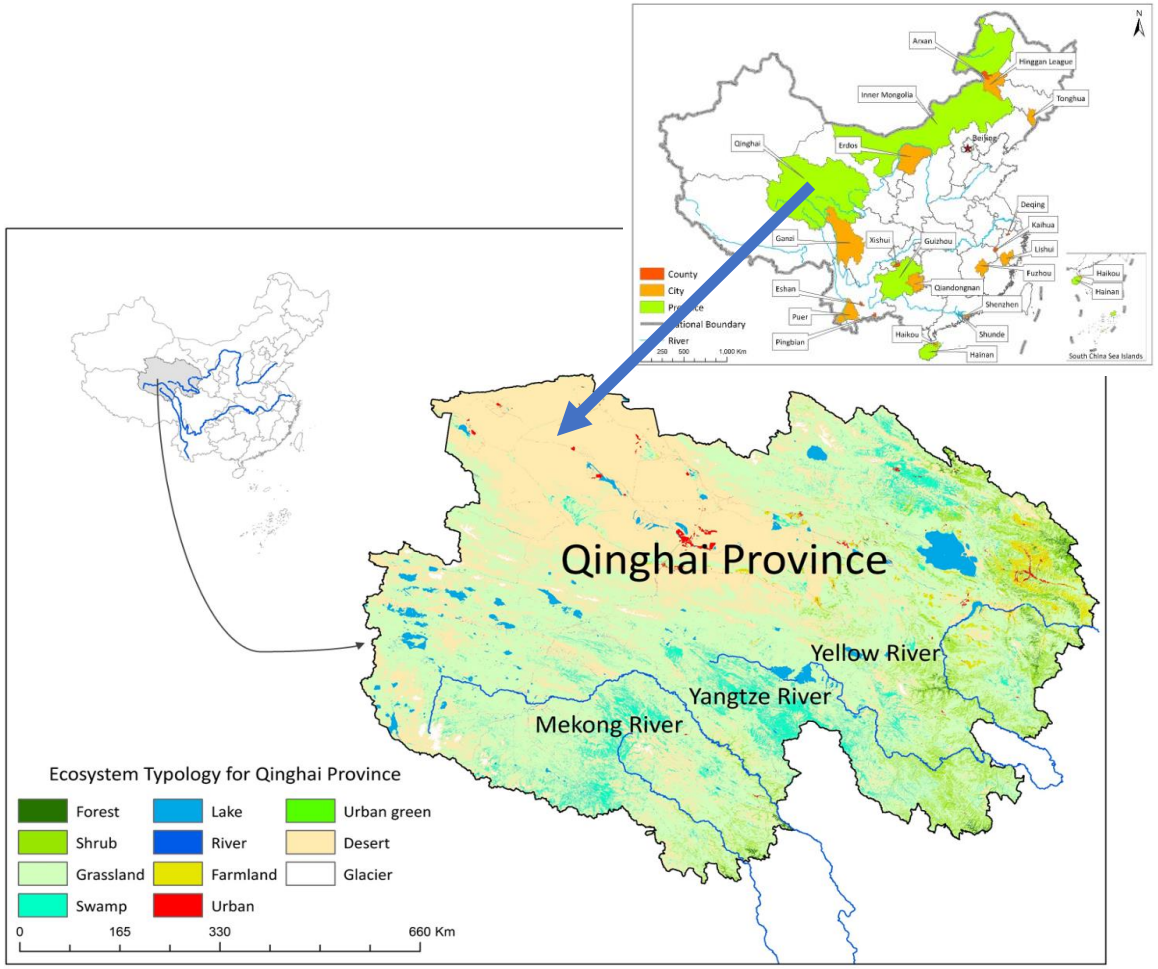
- ✓ 4 provinces
- ✓ + 10 cities/prefectures
- ✓ + 100 counties



GEP pilot accounting-Qinghai

Qinghai Province

- ✓ located in western, on the northeastern part of the Tibetan Plateau
- ✓ Area of 722 thousand km^2, population of 5.8 million.
- ✓ Dominant ecosystem type is grassland, including alpine meadows and alpine steppe.
- ✓ Known as “water tower” of East and Southeast Asia, the source of Yellow River, Yangtze and Mekong Rivers.
- ✓ Global hot spot for biodiversity. It is the home of many endangered species, such as Tibetan antelope, snow leopard, wild yak, Bactrian camel, Asiatic wild ass, Black-necked Crane and Snowcock



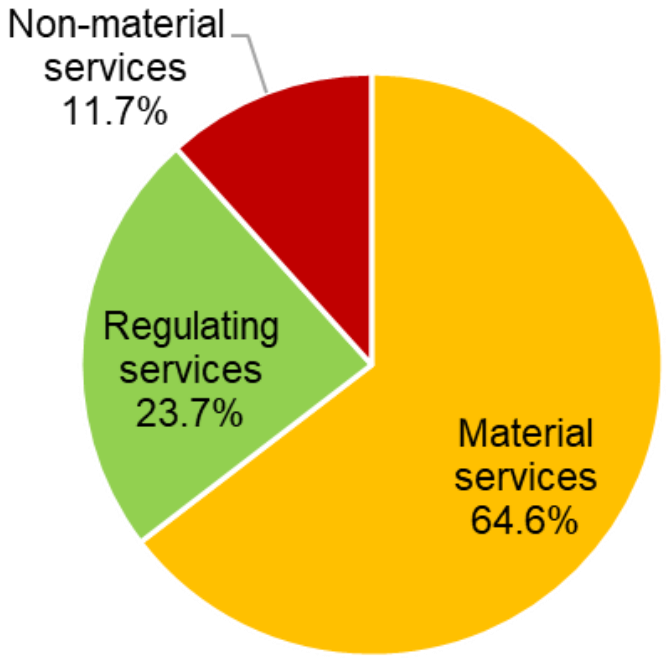
GEP pilot accounting-Qinghai

Types of service	Category of ecosystem services	Accounting items	2015		
			Bio-physical quantity	Monetary value(Billion Yuan)	% of total value
Material services	Production of ecosystem goods	Agricultural crop production ($x10^3$t)	3091.2	5.6	3.0
		Animal husbandry production ($x10^3$t)	724	5.8	3.1
		Fishery production ($x10^3$t)	10.6	0.3	0.1
		Forestry production ($x10^3$t)	10.4	0.7	0.4
		Plant nursery production ($x10^9$)	11	0.7	0.4
	Water supply	Water use in downstream agricultural irrigation ($x10^9$ m^3)		15	8.1
		Water use in households ($x10^9m^3$)		13.8	7.4
		Water use in industry ($x10^9m^3$)		29.2	15.8
		Hydropower production ($x10^9$ kwh)	92	48.8	26.3
Regulating services	Flood mitigation	Flood mitigation ($x10^9m^3$)	0.07	0.03	0.02
	Soil retention and	Retained soil ($x10^9$ t)	0.4	7	3.8
	non-point pollution prevention	Retained N ($x10^3$ t)	10	0.02	0.01
		Retained P ($x10^3$t)	0.7	0.002	0.001
	Water purification	COD purification ($x10^3$ t)	104.3	0.1	0.1
		NH-N purification ($x10^3$ t)	10	0.02	0.01
		TP purification ($x10^3$ t)	0.9	0.003	0.001
	Air purification	SO_2 purification ($x10^3$ t)	150.8	0.2	0.1
		NO_x purification ($x10^3$ t)	117.9	0.1	0.1
		Dust purification ($x10^3$ t)	246	0.04	0.02
	Sandstorm prevention	Sand retention ($x10^9$t)	0.5	31.7	17.1
	Carbon sequestration	Carbon sequestration ($x10^9$ t)	0.02	4.7	2.5
Non-material services	Eco-tourism	Tourists （$x10^6$ persons）	23.2	21.6	11.7
Grand Total				185.4	100.0

GEP pilot accounting-Qinghai

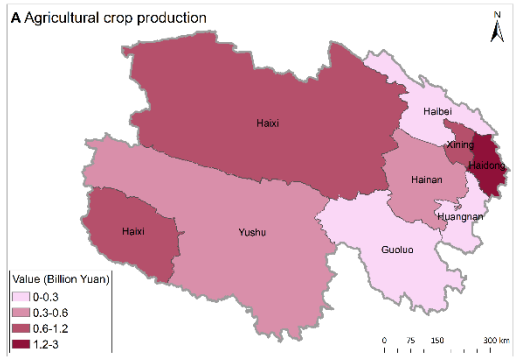
GEP of Qinghai in 2015：185.5 Billion

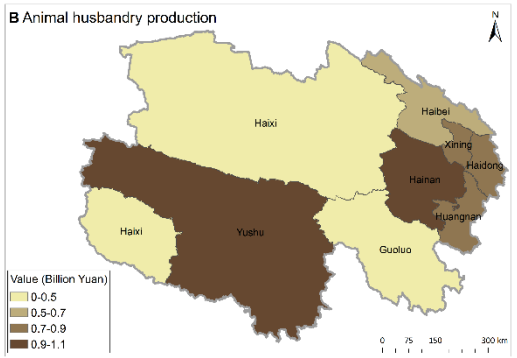
Items	Value (billion yuan)	Ratio (%)
Material services	119.8	64.6
Regulating services	43.9	23.7
Non-material services	21.6	11.7
Total	185.6	100.0

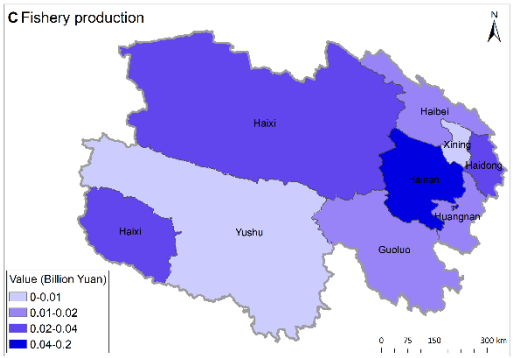


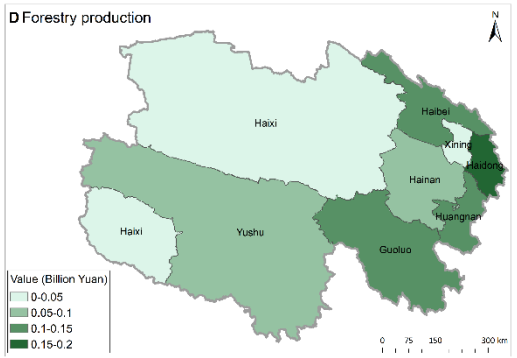
GEP pilot accounting-Qinghai

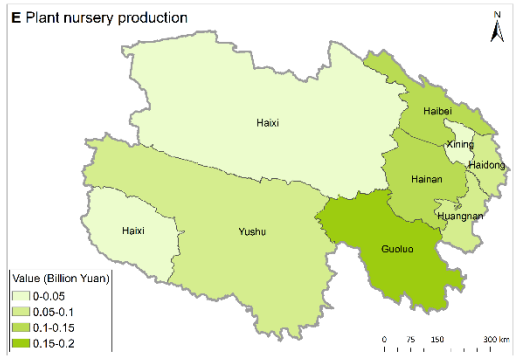
Spatial distribution of ecosystem services are produced within Qinghai

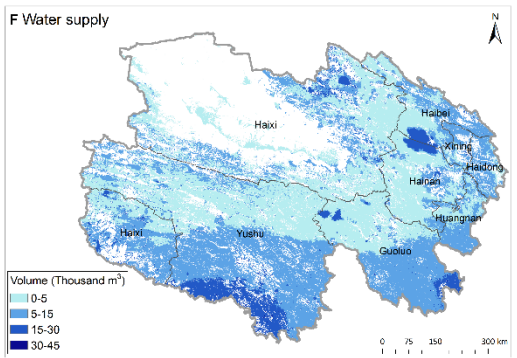


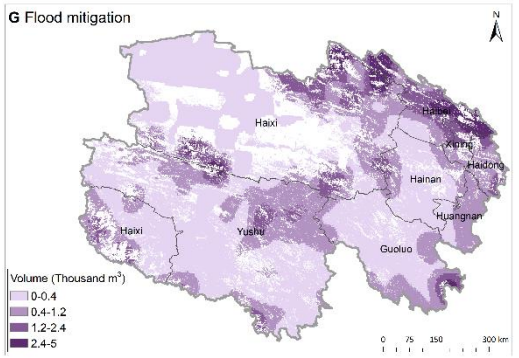


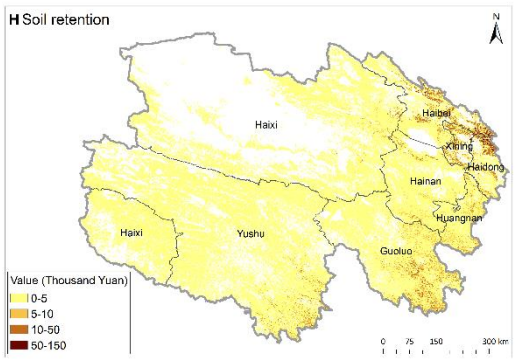


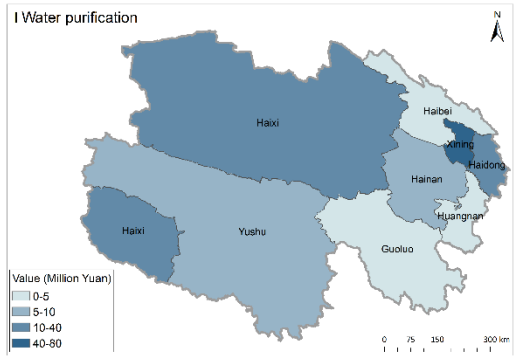


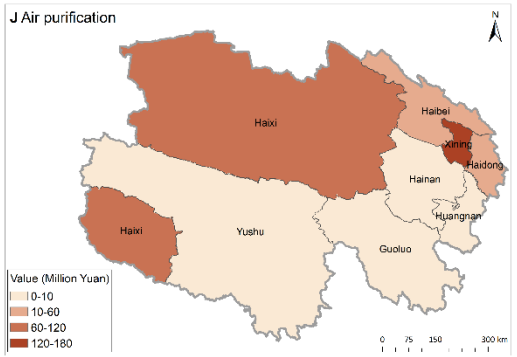


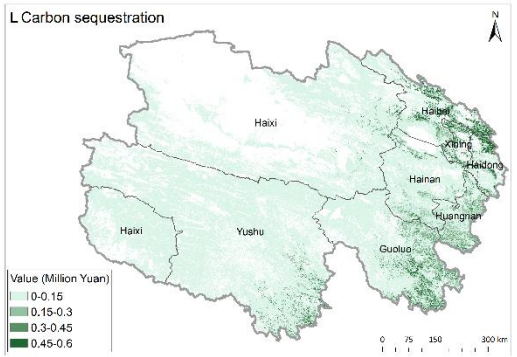






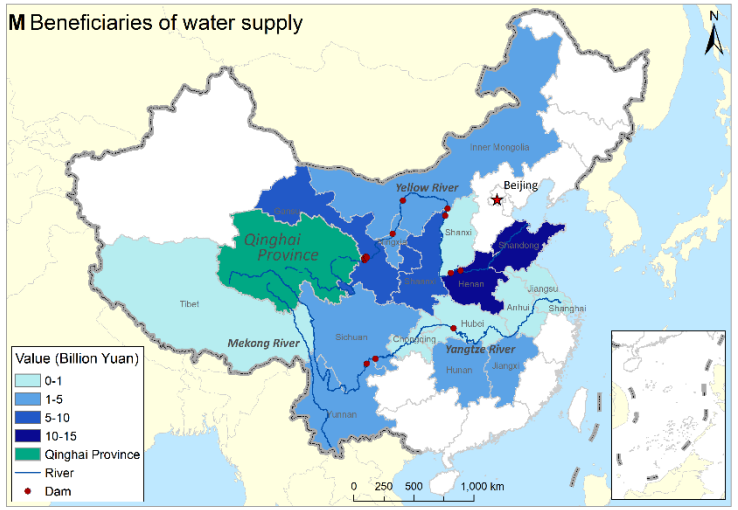


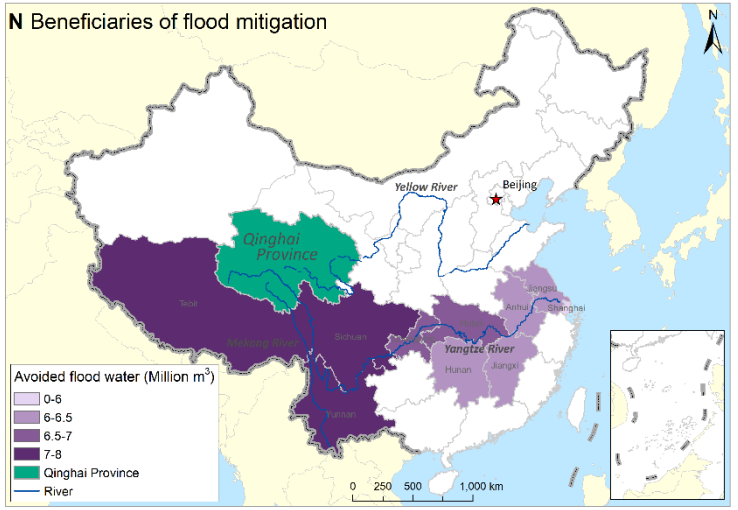


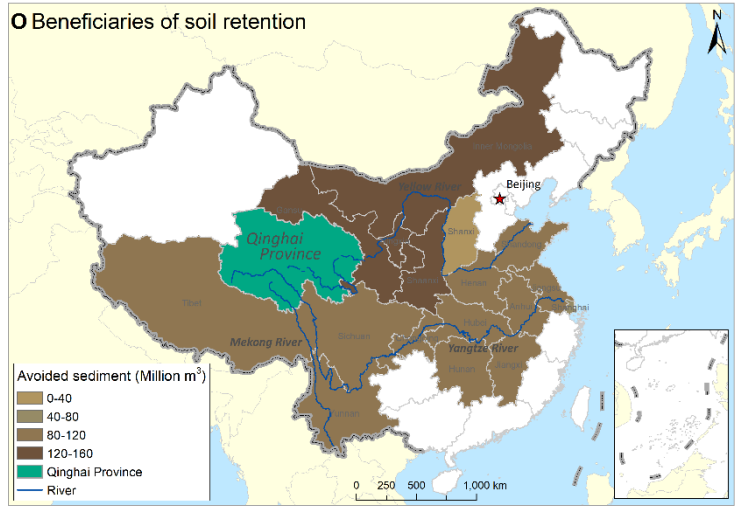


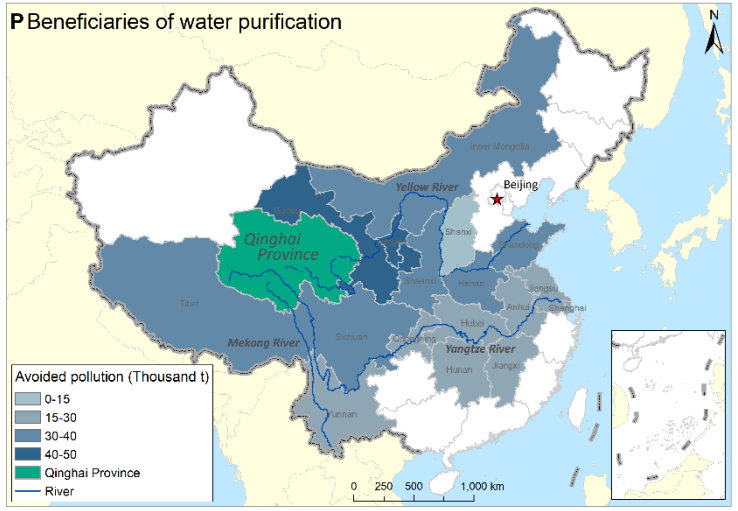
GEP pilot accounting-Qinghai

Beneficiaries in recipient provinces in China









GEP pilot accounting-Qinghai

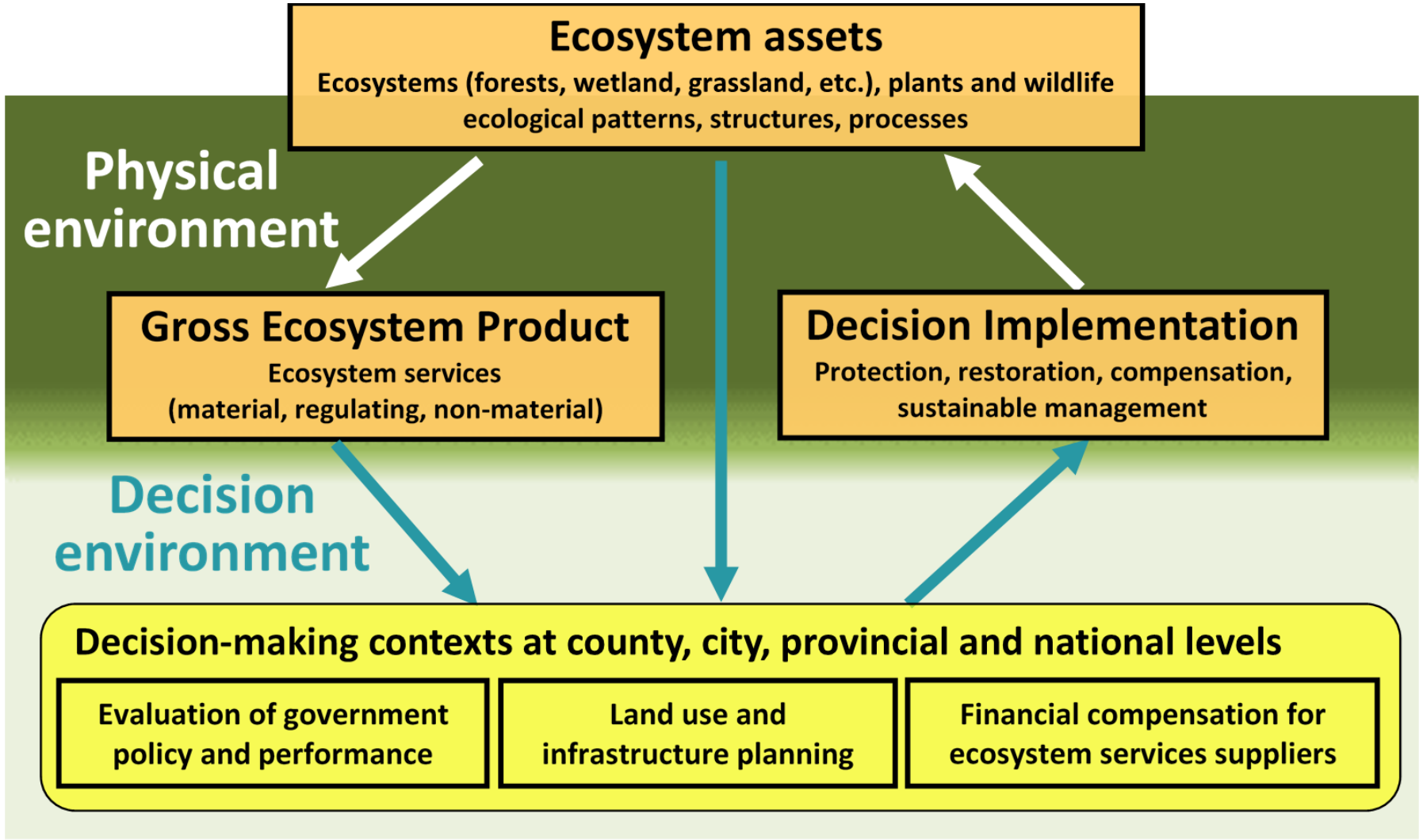
Changes of the GEP in Qinghai Province (2000–2015)

Services	2015 (Billion Yuan)	2000 (Billion Yuan)		2000–2015 (current price)	2000–2015 (constant price)
		Current price	Constant price	Rate of change (%)	Rate of change (%)
Material services	119.8	50.3	65.6	138.6	82.6
Regulating services	43.9	28.3	40.0	55.3	9.8
Non-material services	21.6	3.0	4.2	621.3	408.8
GEP	185.6	81.5	109.8	127.5	68.8

Ouyang ZY, Song CS, Zheng H, Polasky S, Xiao Y, Bateman IJ, Liu J, Ruckelshaus M, Shi F, Xiao Y, Xu W, Zou Z & Daily G. Using Gross Ecosystem Product (GEP) to Value Nature in Decision-Making. *PNAS.* 2020, 117(25): 14593-14601.

Applications of GEP accounting

Applications of GEP accounting



Applications of GEP accounting

The government of China is actively working to develop and implement GEP

Project goals	Supporting Agencies
Develop GEP accounting frameworks and methods Test the frameworks and methods in different regions	CAS
Establish technical guidelines and pilot study for EA and GEP accounting at provincial, city, and county levels	MOST, SAC, MEE
Establish technical guidelines and implementation for GEP accounting to evaluate overall effectiveness of eco-compensation programs at provincial, city, and county levels	NDRC, ADB
Develop GEP-based indices for evaluating government performance of counties in key ecological function zones; suggest policies for implementation	NDRC
Carry out national GEP accounting, and training for provincial, city, and county agencies	MEE
Implement GEP accounting for eco-compensation	Yunnan – Pu'er city
GEP accounting and application in assessment of effectiveness of conservation and restoration	Guizhou, Hainan, Inner Mongolia, Jilin– Tonghua, Sichuan –Ganzi, et,al
GEP and ecological asset accounting and evaluate conservation performance of township governments in Shunde district	Guangdong – Shunde District
GEP t accounting and application in urban management and city sustainability	Guangdong-Shenzhen
GEP accounting and application in effectiveness of conservation and green development	Zhejiang-Lishui city, Jiangxi-Fuzhou city

Applications of GEP accounting

Applications of GEP measurement mainly in following aspects

- Evaluation of government policy and performance in conservation. NDRC, MEE, Inner-Mongolia, Guizhou, Qinghai, Zhejiang, Shenzhen, Shunde, Tonghua
- Provide the basis for determining financial compensation for the provision of ecosystem services. Lishui, Pu'er, Zhejiang
- To evaluate sustainable development (harmony of people and nature), Shenzhen, Zhuhai
- Bringing the value of ecosystem services and trends into public and private sector decision making and investment planning. Zhejiang, Lishui, Fuzhou, Alibaba
- Measure the natural contribution to people, other parts of China. Qinghai, Ganzi

Findings and challenges

Findings and challenges

Findings

- GEP converts ecosystem services into a common monetary metric that is easy to interpret, provides visibility, and gives prominence to the values of nature and their contributions to human well-being.
- GEP can provide decision makers with clear and compelling evidence of the monetary value of ecosystem services.
- GEP can be applied for evaluation of government policy and performance, and land use and infrastructure planning.
- GEP can provide the basis for determining financial compensation for the provision of ecosystem services.
- The Qinghai results demonstrate that it is feasible to produce an estimate of GEP with available data and methods: That is, that there is a tractable approach to producing estimates of GEP, not just in Qinghai but all across China, and indeed for all countries in the world.

Findings and challenges

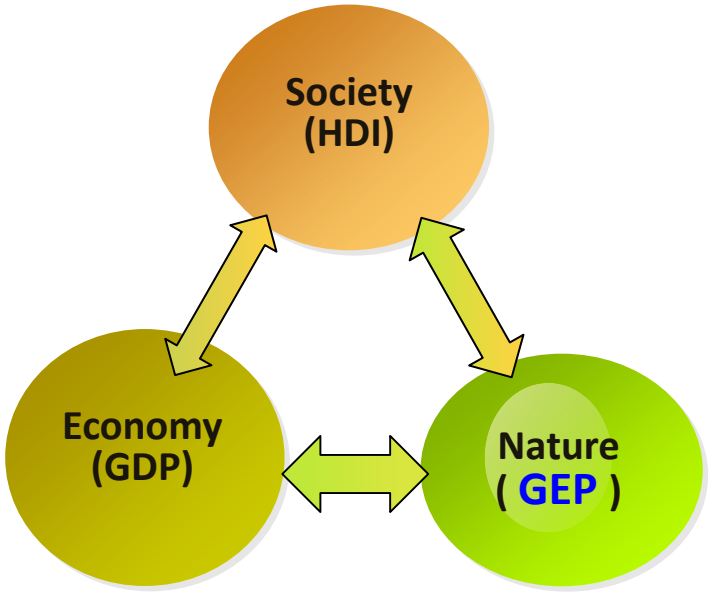
Challenges

- ✓ **Data limitations.** Current environmental monitoring systems are not designed for ecosystem service evaluation and accounting
- ✓ **Methods and models** for ecosystem services. Many models to quantify ecosystem services are in the early stages of development.
- ✓ **Pricing of ecosystem services**. Particularly, the ecosystem services do not exist market prices.
- ✓ **Accounting value**. Lack of data that allows attribution of value added between nature and human contributed inputs.
- ✓ **The set of ecosystem services** in pilot GEP accounting in China still represents an incomplete set of ecosystem services. In Qinghai GEP accounting, for instances, we did not include the value of oxygen generation (O_2 is extremely important in Qinghai and Tibetan Plateau), many human health benefits from nature, and cultural services other than ecotourism

Findings and challenges

Suggestions

- ✓ Standardize definitions and methods to compute GEP.
- ✓ Updating existing monitoring system for the purpose to provide data for GEP accounting.
- ✓ GEP can be a choice as an indicator of SEEA-EA, like GDP the indicator of SNA.
- ✓ Pilot GEP accounting in different countries.



GEP Team and collaborators

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- **Natural Capital Project**
  - ✓ **Gretchen Daily, Mary Ruckelshaus**, Stanford University
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- **Chunquan Zhu**, IUCN-China
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- **SEEA-EA team, UNSD**

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