

Gross Ecosystem Product (GEP)

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- ✧ GEP definition and vision
- ✧ GEP accounting framework
- ✧ GEP pilot accounting
- ✧ GEP applications
- ✧ Findings and challenges

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

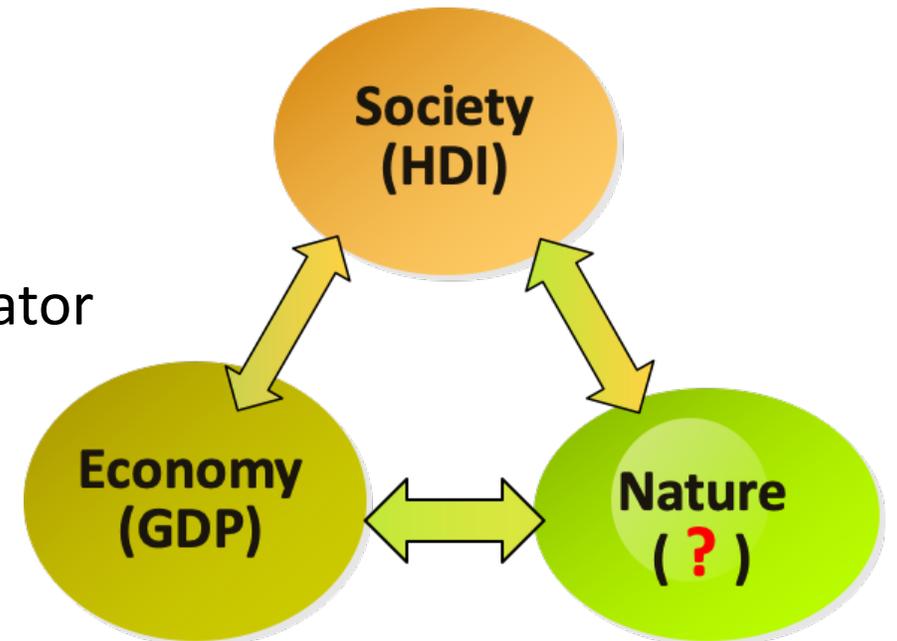


Gross Ecosystem Product

What is GEP?

Need a metric to measure nature's contribution to people

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



In order to advance an ecological civilization in China

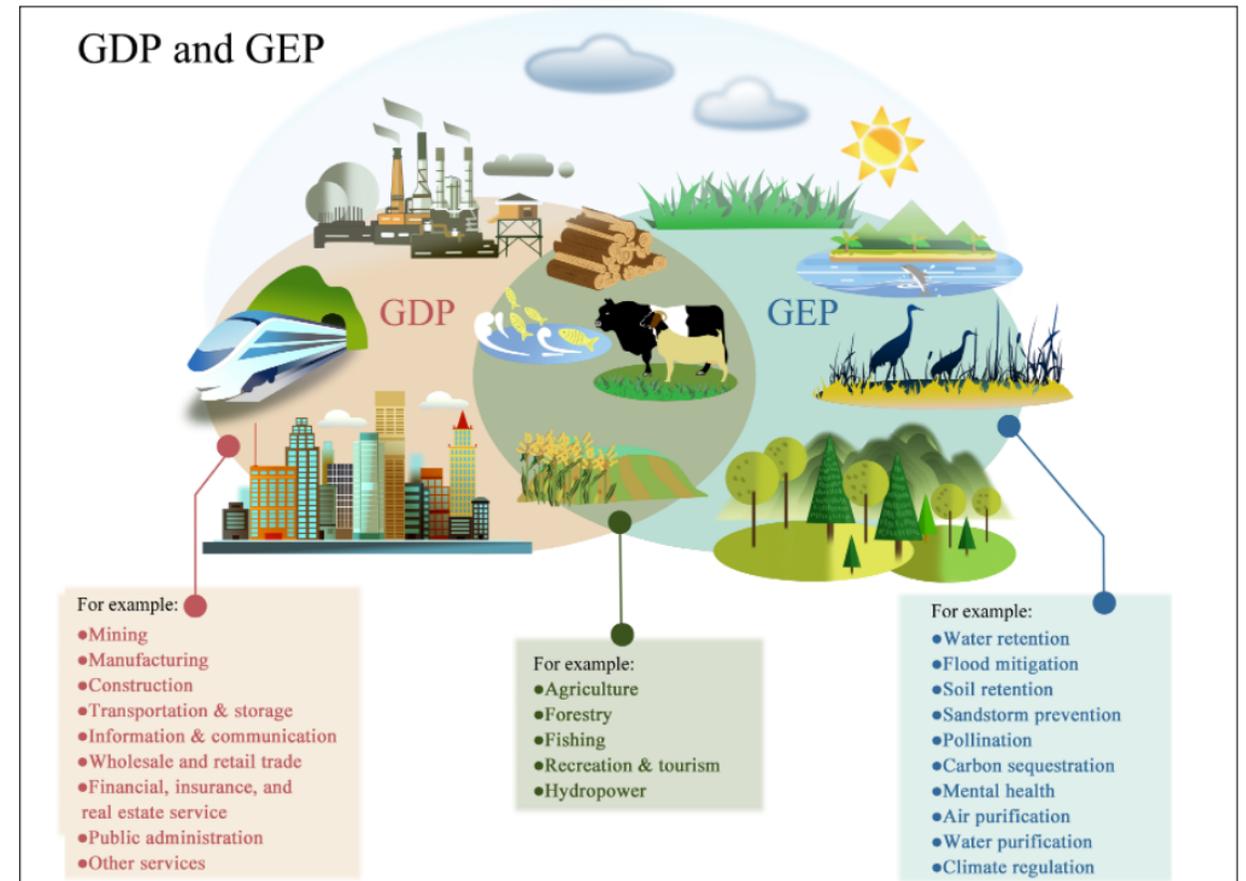
- ✧ President Xi put forward the vision “**Clear water and green mountains are gold and silver mountains**”, to give prominence to nature’s value for people
- ✧ This involves:
 1. **Integration of ecological benefits** into criteria for performance evaluation of local governments
 2. Establishment of **eco-compensation policy & investment mechanisms** based on ecosystem services
 3. Establishment of a **natural capital accounting system** to support 1 & 2

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, such as a forest, grassland, wetland, coral reef, farm, city park, and other natural or managed ecosystems.



GDP and GEP



For example:

- Mining
- Manufacturing
- Construction
- Transportation & storage
- Information & communication
- Wholesale and retail trade
- Financial, insurance, and real estate service
- Public administration
- Other services

For example:

- Agriculture
- Forestry
- Fishing
- Recreation & tourism
- Hydropower

For example:

- Water retention
- Flood mitigation
- Soil retention
- Sandstorm prevention
- Pollination
- Carbon sequestration
- Mental health
- Air purification
- Water purification
- Climate regulation



Accounting framework of GEP

(How to Measure GEP)

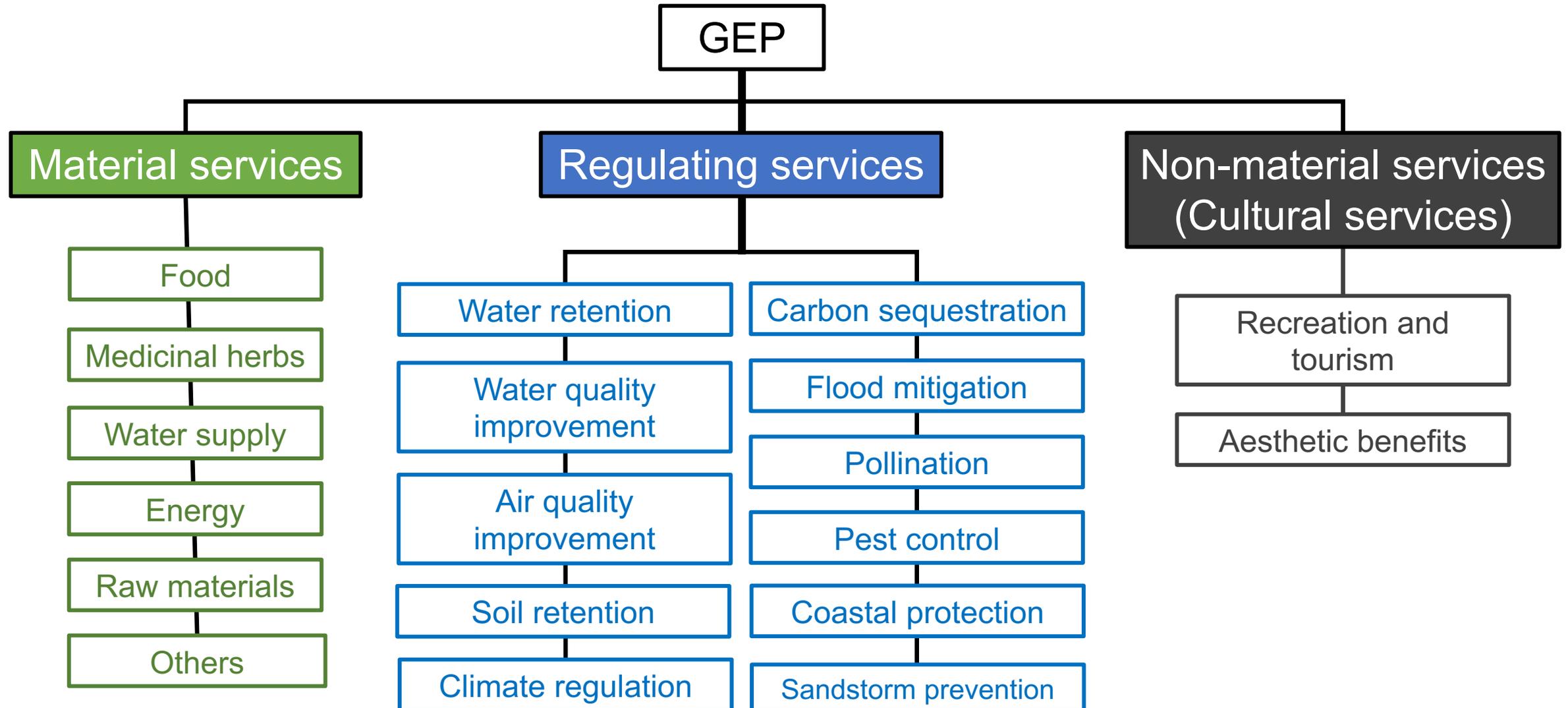
Criteria for GEP accounting

- ✧ GEP is a measurement of the aggregate monetary value of ecosystem-related goods and services in the accounted areas
- ✧ 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 ecosystem services
 - ✓ Material services (ecosystem goods), regulating services, and non-material services
- ✧ First, measure biophysical value (quantity)
 - ✓ E.g., amount of food production, amount of water purification, amount of flood protection
- ✧ Second, measure monetary value (value added per unit x quantity)
 - ✓ The economic value of ecosystem services



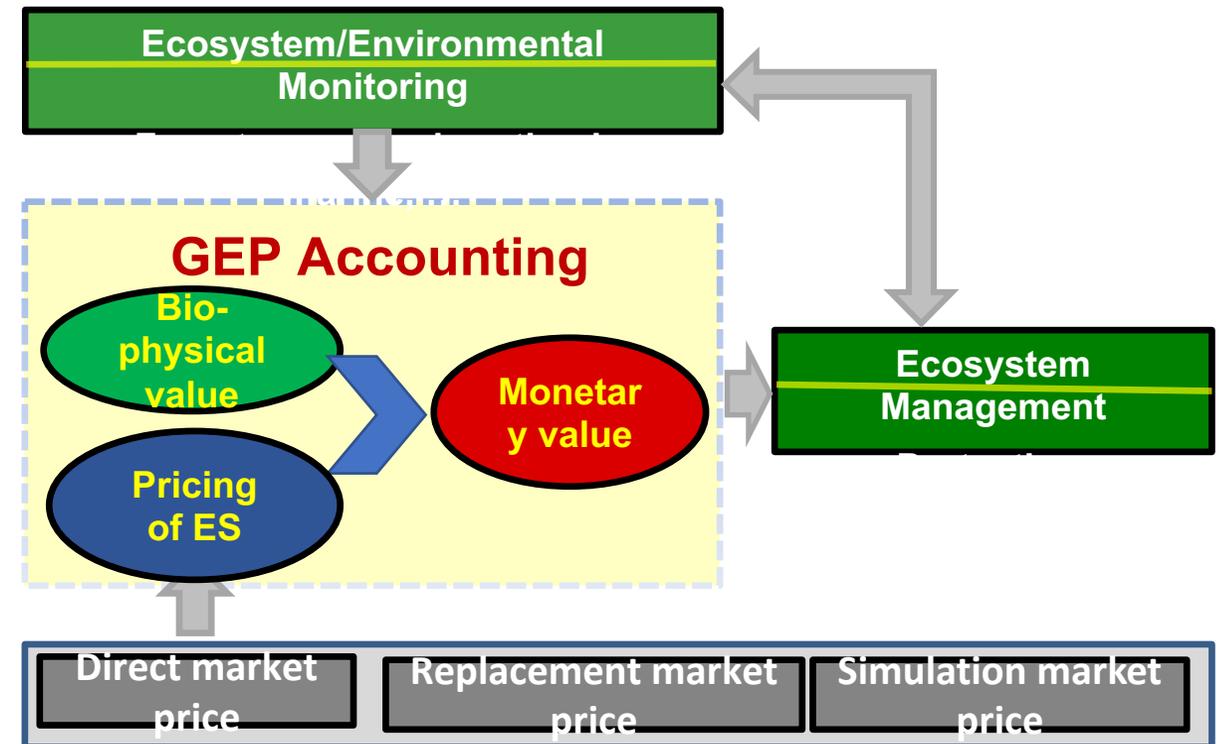
GEP accounting framework

Ecosystem services in GEP accounting



GEP accounting framework

- Make list of ecosystem services for accounting area
- Accounting of bio-physical values of ecosystem goods and services
- Pricing ecosystem goods or services
- Accounting of monetary values of ecosystem goods and services



$$GEP = EMV + ERV + ECV$$

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

EMV: monetary value of ecosystem material services
 ERV: monetary value of ecosystem regulating services
 ECV: monetary value of ecosystem non-material (cultural) services.



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	Replacement market method	
	Water retention	Amount of water retention	Water Balance Equation	Value of water retention		
	Soil retention	Amount of soil retention	RUSLE	Value of sediment reduction		
	Flood mitigation	Lake: adjustable storage capacity	Monitoring data	Hydrologic data		Value of flood mitigation
		Reservoir: flood control storage				
		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	



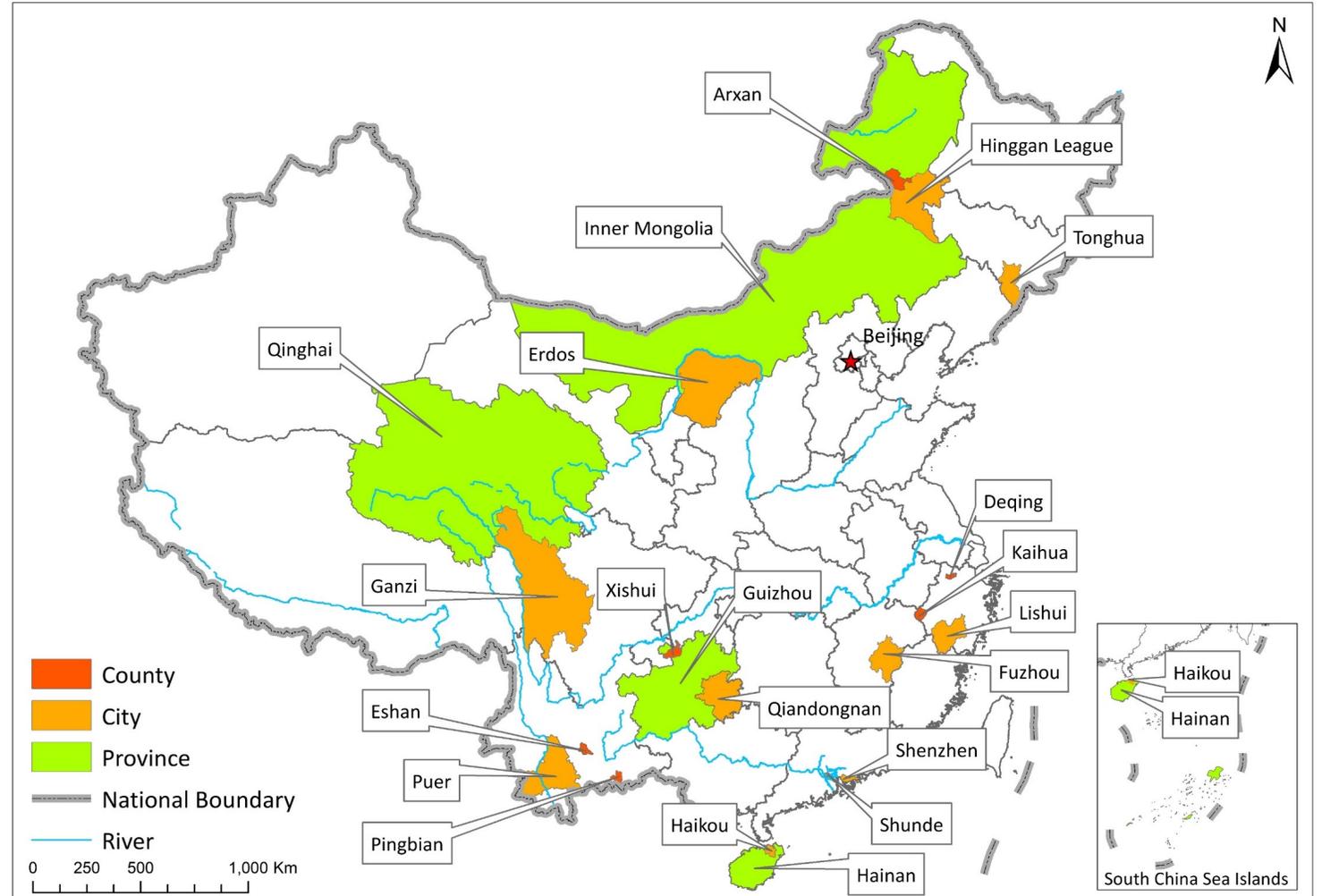
GEP pilot accounting in China



GEP pilot accounting

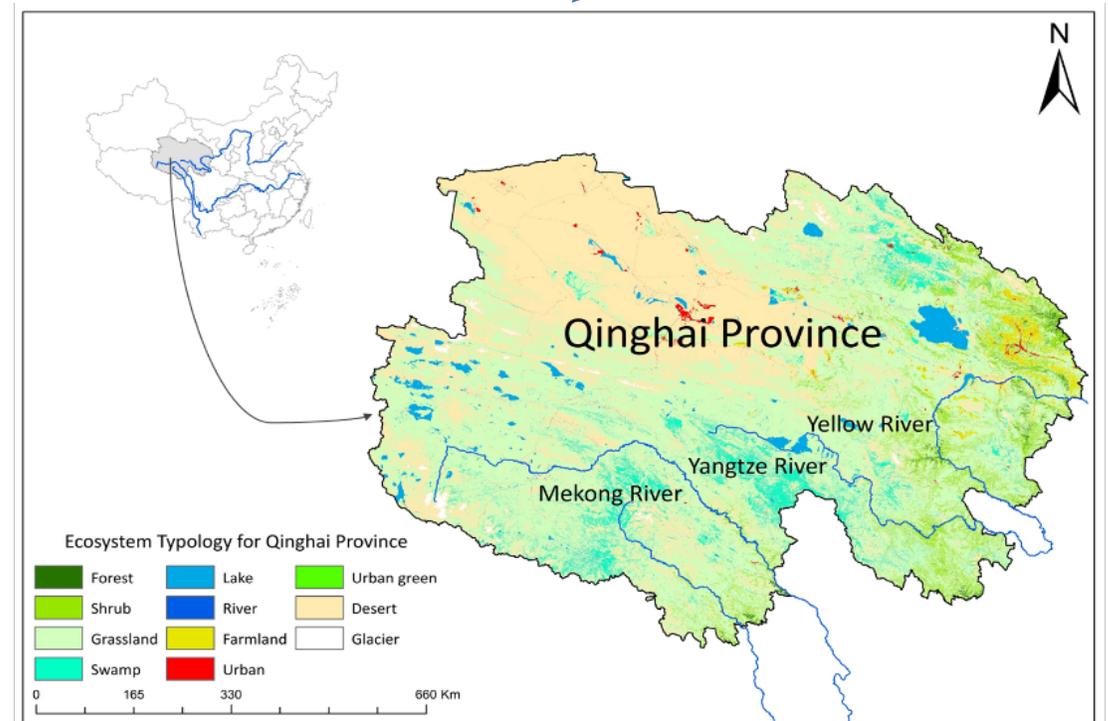
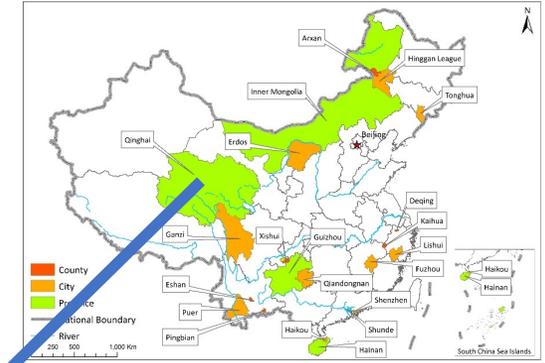
Pilot GEP accounting in China

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



Qinghai Province

- ✓ In western China, part of the Tibetan Plateau
- ✓ Known as “water tower” of East and Southeast Asia, source of Yellow, Yangtze and Mekong rivers
- ✓ 722,000 km² area, 5.8 million people
- ✓ Dominant ecosystem type is grassland, including alpine meadows and alpine steppe
- ✓ Global hot spot for biodiversity, home of many endangered species, such as Tibetan antelope, snow leopard, wild yak, Bactrian camel, Asiatic wild ass, Black-necked Crane and Snowcock



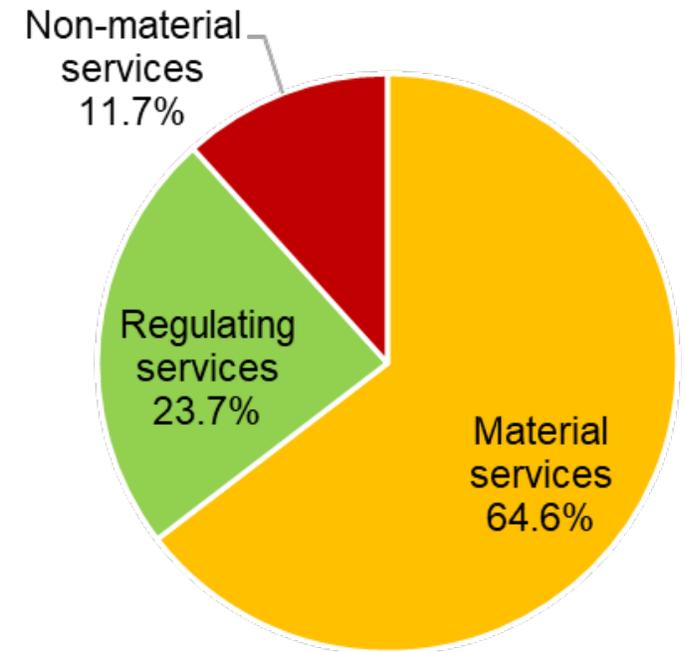


GEP pilot accounting-Qinghai

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 ⁹ m ³)		13.8	7.4
		Water use in industry (x10 ⁹ m ³)		29.2	15.8
		Hydropower production (x10 ⁹ kwh)	92	48.8	26.3
Regulating services	Flood mitigation	Flood mitigation (x10 ⁹ m ³)	0.07	0.03	0.02
	Soil retention and non-point pollution prevention	Retained soil (x10 ⁹ t)	0.4	7	3.8
		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	
Cultural services	Eco-tourism	Tourists (x10 ⁶ persons)	23.2	21.6	11.7
Grand Total				185.4	100.0

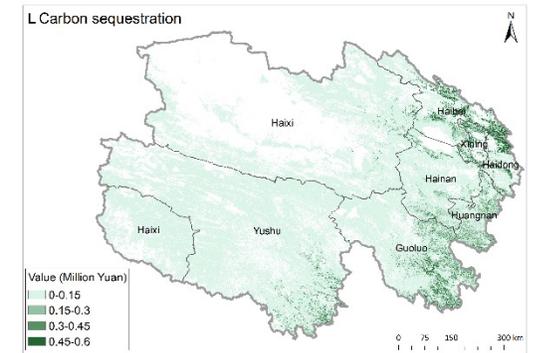
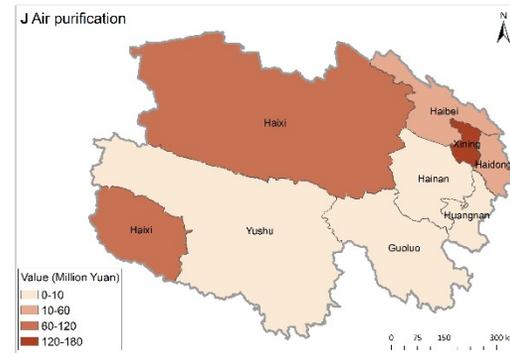
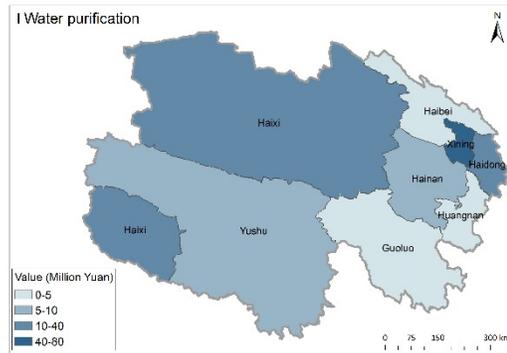
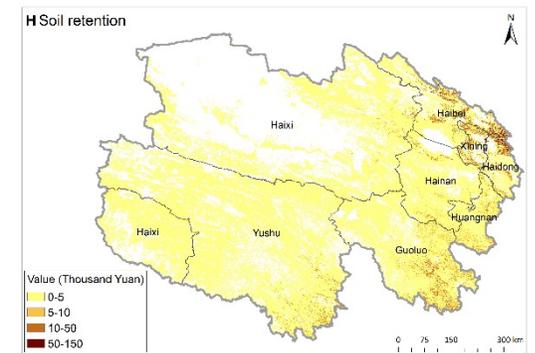
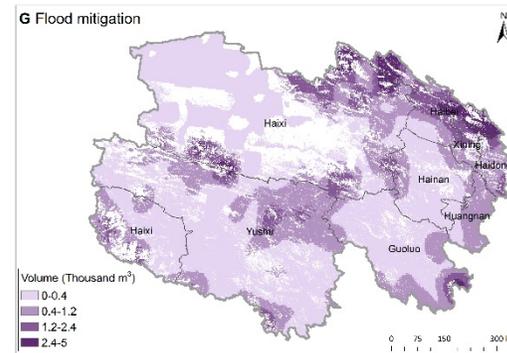
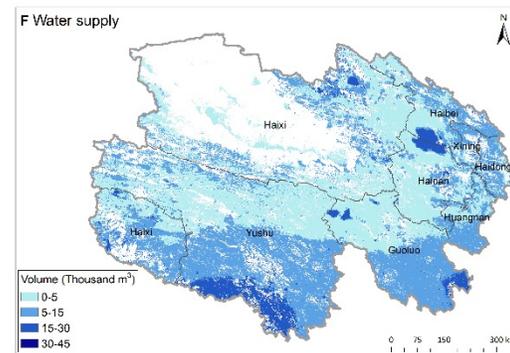
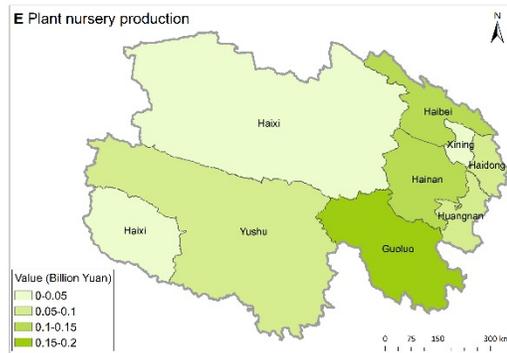
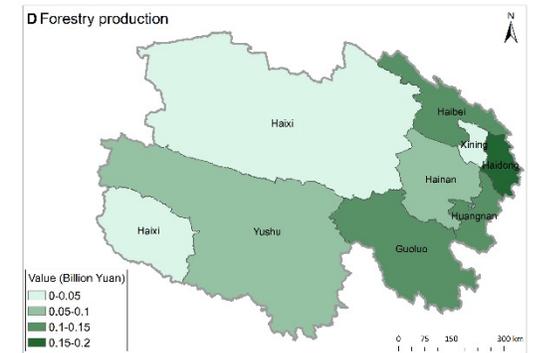
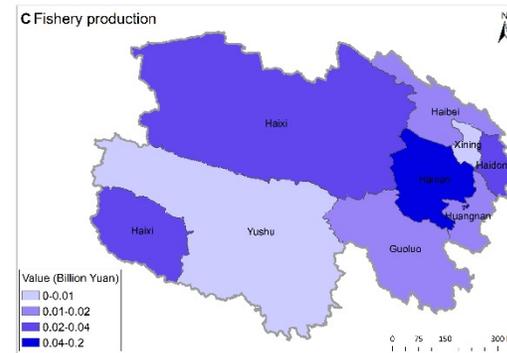
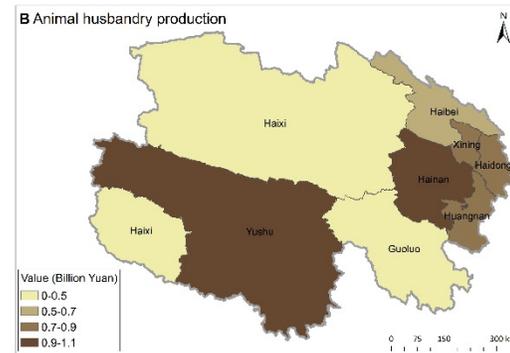
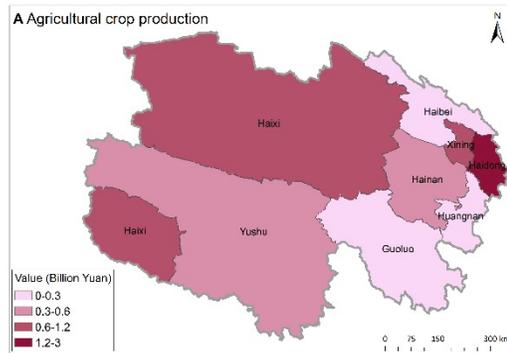
GEP of Qinghai in 2015: 185.5 Billion

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



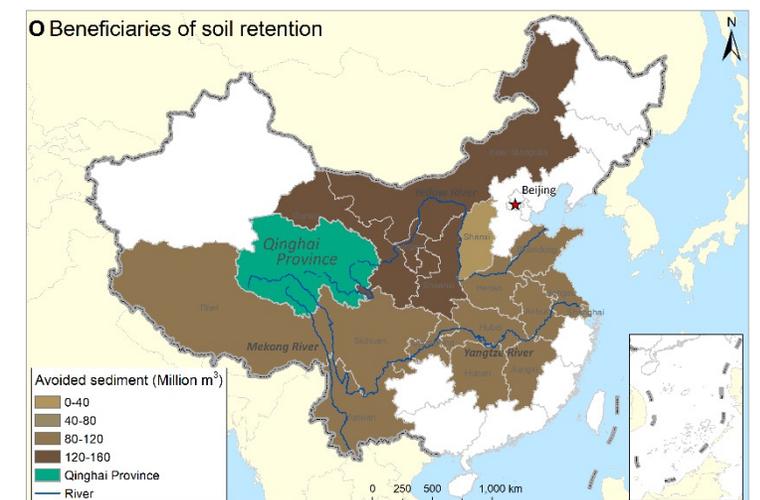
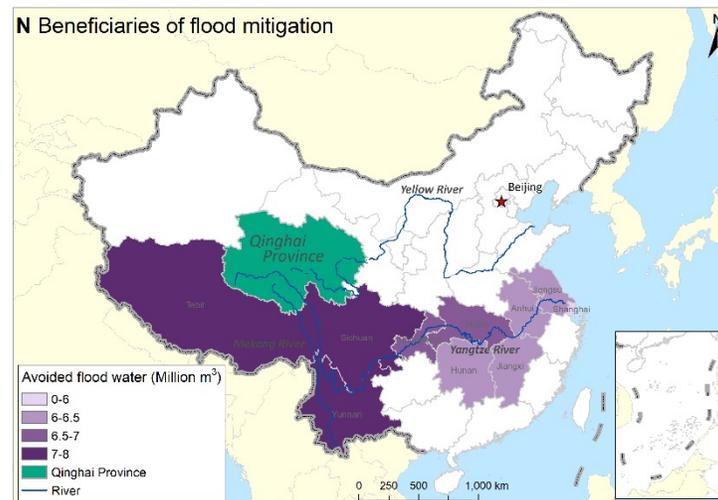
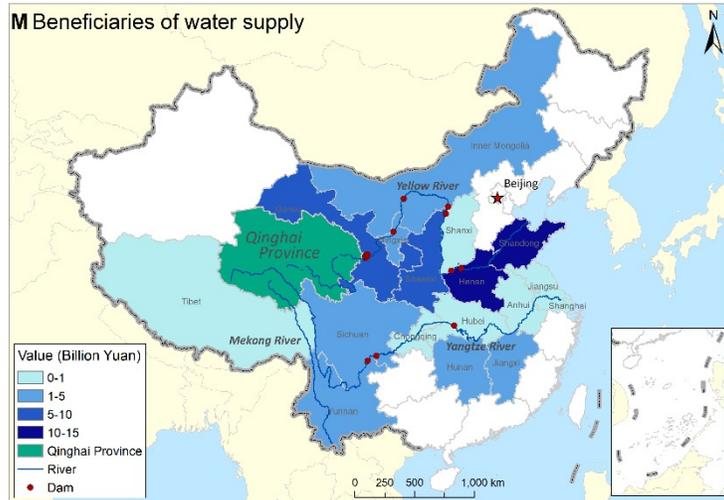
(Ouyang *et al.* 2020 PNAS)

Spatial distribution of ecosystem services are produced within Qinghai



GEP pilot accounting-Qinghai

Beneficiaries in recipient provinces in China



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

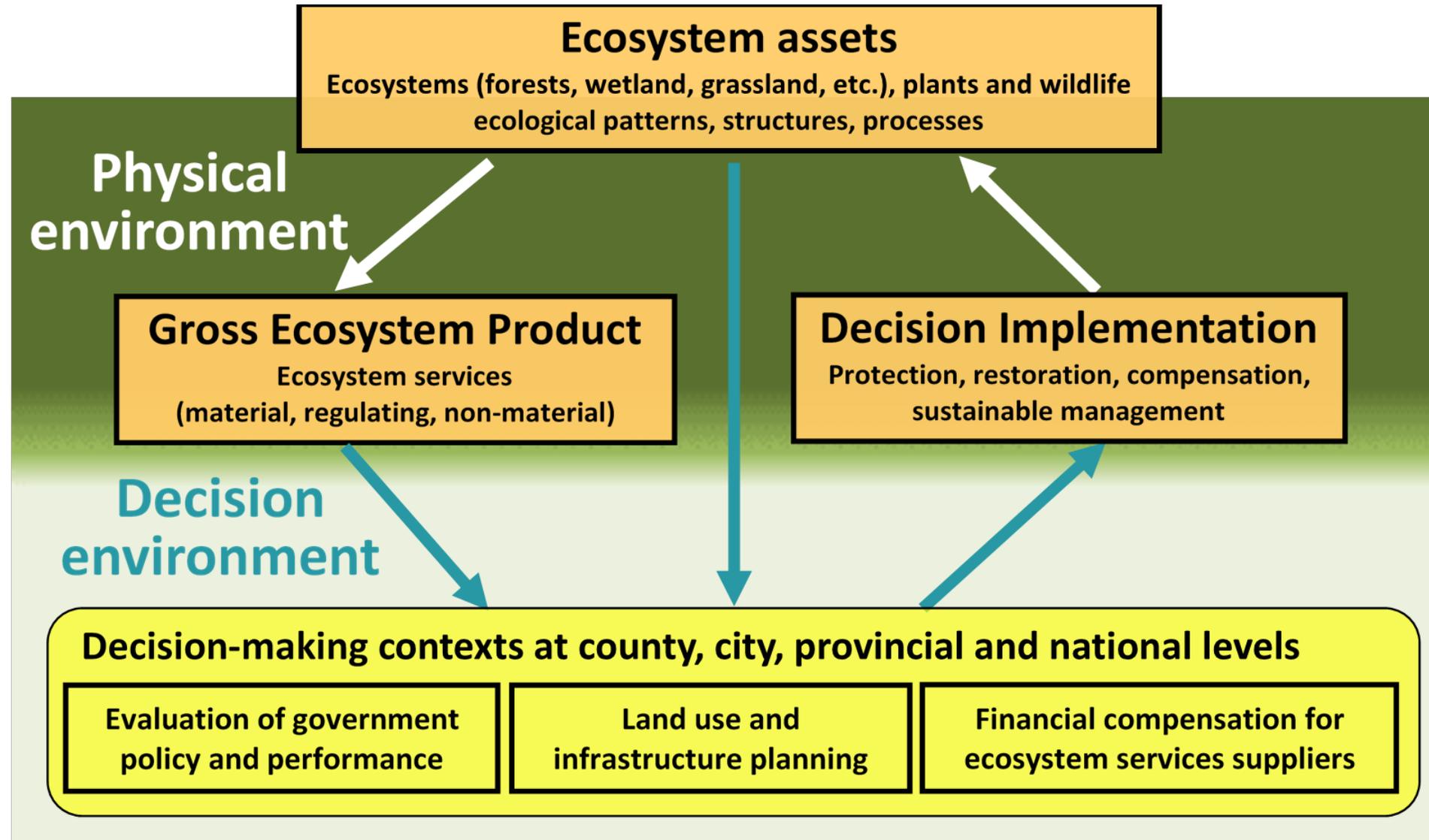
Services	2015 (Billion Yuan)	2000 (Billion Yuan)		2000–2015 (current price)	2000–2015 (constant price)
		Current price	Constant price	Rate of change (%)	Rate of change (%)
Material services	119.8	50.3	65.6	138.6	82.6
Regulating services	43.9	28.3	40.0	55.3	9.8
Non-material services	21.6	3.0	4.2	621.3	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 GC. 2020. Using Gross Ecosystem Product (GEP) to Value Nature in Decision-Making. *PNAS* 117: 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 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 in key realms ~ by central government, provinces, cities, companies

- ✦ Evaluating government policy and performance in conservation. **NDRC, MEE, Inner-Mongolia, Guizhou, Qinghai, Zhejiang, Shenzhen, Shunde, Tonghua**
- ✦ Providing the basis for determining financial compensation for the provision of ecosystem services. **Lishui, Pu'er, Zhejiang**
- ✦ Evaluating 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**
- ✦ Measuring nature's contribution to people, and to 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

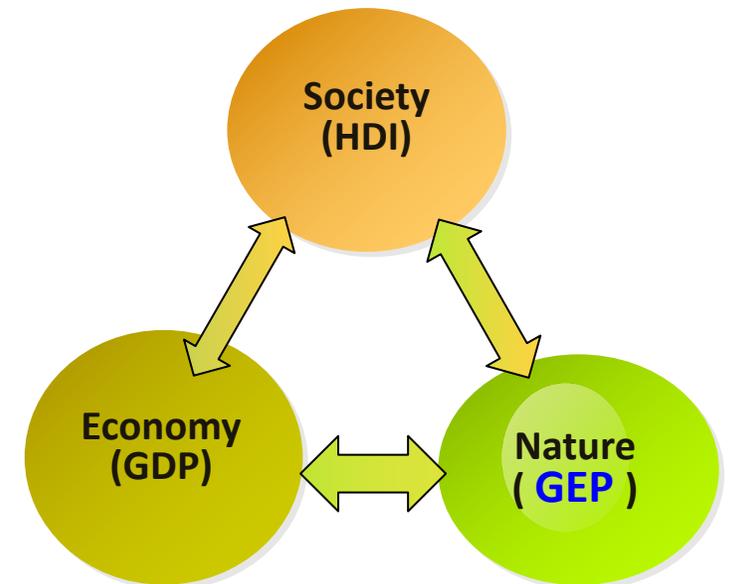
- ✓ **Data limitations.** Current environmental monitoring systems are not designed for ecosystem service evaluation and accounting.
- ✓ **Models** for quantifying many ecosystem services are in early stages of development. Focus initially on a core set of services for which science is advanced and robust.
- ✓ **Pricing of ecosystem services.** There are no market prices for most ecosystem services.
- ✓ **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 is incomplete. In Qinghai GEP accounting, for instance, 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
- ✓ Update existing monitoring system for the purpose of providing data for GEP accounting
- ✓ Pilot GEP accounting in different countries, in pragmatic ways that drive investment in green, inclusive development.





GEP Team and collaborators

- ✧ **Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences**
 - ✓ **Zhiyun Ouyang, Hua Zheng, Yi Xiao, Changsu Song, Ziyang Zou, Tong Wu, et al.**
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IUCN-China