

# Accounting Gross Ecosystem Product (GEP) Zhiyun Ouyang

Research Center for Eco-Environmental Sciences, Chinese academy of Sciences

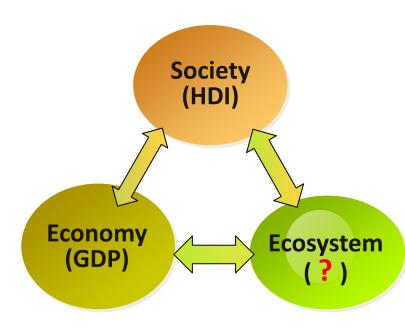
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- 1. Background
- 2. GEP Concept and accounting framework
- 3. GEP accounting in China
- 4. On-going



#### Community is a coupled nature-economic-social system

- Economy: GDP 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 living-standard since 1991.
- Natural environment: currently we do not have widely used index to measure its sustainability.



- ★ Ecosystem is essential for human survival and development
  - Creating and maintaining living supporting system of the Earth: water cycling, soil formation and fertility, atmosphere chemistry stable.
  - ✓ Providing human with food fiber, water, bio-energy.
- ★ Ecosystem services: the benefits human-being obtained from the nature/ecosystems (MA, 2003).



- → Both developed and developing countries are attempting to find new accounting indicators or accounting system beyond GDP, to quantify the linkage between ecosystems and human well-being.
- → The creation of a new system to account for ecosystem goods and services at national or regional scales has become a hot international topic for advancing the sustainable development agenda.



# Natural /Ecosystem service evaluation is the hot topic globally, and used as an indicator for assessing sustainability

- ✓ UN: IPBES (Inter-government platform for Biodiversity and Ecosystem Services), 2012-
- ✓ UN: Millennium Ecosystem Assessment, 2003-2008
- ✓ UNSD, SEEA (Environmental and economic accounts), 2003, 2012
- ✓ UNSD, Land and ecosystem accounts, 2012.
- ✓ World Bank, Wealth accounting and valuation of ecosystem services
- ✓ TEEB, The Economics of Ecosystems and Biodiversity, 2010.
- ✓ EEA(European Enviont. Agency), Simplified ecosystem capital accounts
- Australia, Ecosystem Accounting—Policy Applications, 2012
- ✓ SC (Statistics Canada), Measuring ecosystem goods and services.
- ✓ China, Ecosystem survey assessment of China



## Chinese government initiated eco-civilization and related policies

- Integrated ecological benefits into economic and social development evaluation system.
- Establish eco-compensation policy, reflecting the market demand and resource scarcity, as well as ecological value and inter-generational compensation.
- Improve accountability system of ecological and environmental protection and environmental damage compensation system.
- Establish natural capital accounting system.



#### **Gross Ecosystem Product, GEP**

- → Gross Ecosystem Product (GEP) is the total value of final ecosystem goods and services supplied to people in given region annually, like a county, or a province, a county.
- → GEP is proposed as a comprehensive index based on ecosystem service evaluation.
- ★ Ecosystems (Ecological Assert, EA) is the natural asset providing ecosystem services,
  - Natural ecosystem: forests grasslands, wetland, desert, marine, ...
  - Managed ecosystem: cropland, orchards, aquaculture farms, urban green-space, ...



#### **Ecosystem goods and services**

Categories	Goods and services (examples)				
	Food: grain, vegetable, fruit, meat, milk, egg, fish				
Ecosystem	Materials: wood, fiber, water, genes				
goods	Energy: bio-energy(fuelwood), hydro-power, wind energy				
	Others: medicine, seedling, ornament				
	Regulation services: water conservation, soil conservation,				
Dogulating	carbon sequestration, climate regulating, pollutant				
Regulating	purification, pollination				
services	Protecting services: sand storm prevention, flooding				
	mitigation, pest control				
Cultural comica	Aesthetic services: recreation and ecotourism				
Cultural service	Cultural value: knowledge, education, arts, spirit				

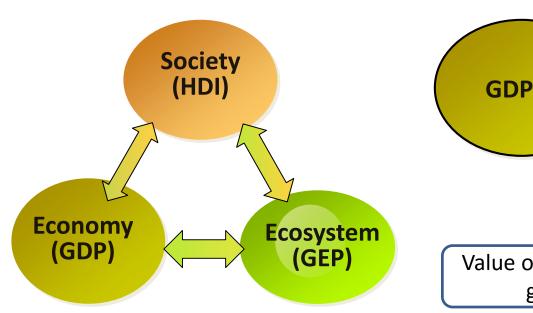


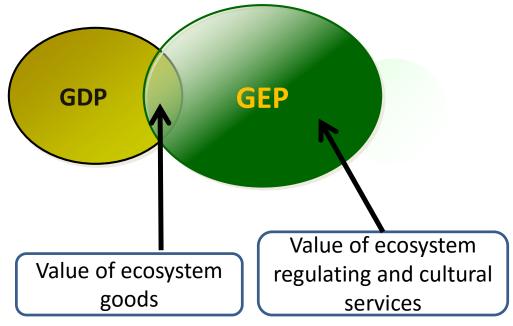
#### **Purposes of GEP accounting**

- ♦ Assessment/description of ecosystem status
- Measurement of community sustainability
- Evaluation of the contribution of ecosystems to human welfare and socio-economic development
- ♦ Evaluation of effects of conservation efforts
- ♦ Reveal the ecological linkages among regions
  - ✓ Ecologically dependency
  - ✓ Ecological supporting



→ GDP, HDI, and GEP

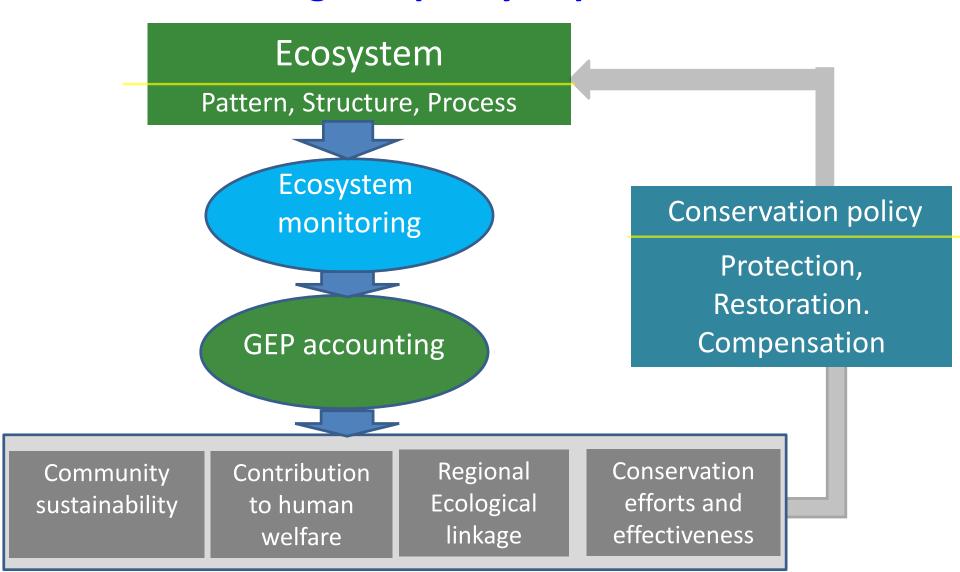


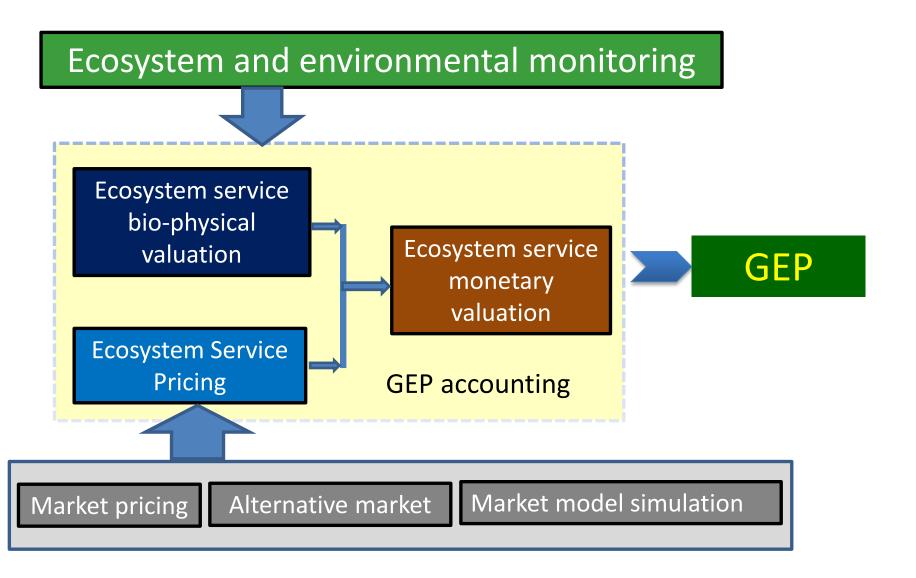


- → GEP, GDP and Green GDP
  - ✓ GEP, The goods and services provided by ecosystems.
  - ✓ GDP, the goods and services provided by economic systems.
  - ✓ Green GDP, the GDP minus natural and environmental costs,



#### **GEP** accounting and policy implementation





## Accounting of bio-physical values of ecosystem goods and services

- Ecosystem Goods: grain, fruit, meat, eggs, vegetables, water, medicinal materials, biological materials, fiber, biomass etc;
- Regulation and culture services: water conservation, soil conservation, contaminants purification, carbon sequestration, oxygen production, aesthetics, recreation, culture identity, knowledge, education, inspiration for art etc..

#### Pricing of ecosystem goods or services

- ✓ timber price, water price, soil conservation price, pollutant purification price,...
- ✓ alternative market, market model simulation methods

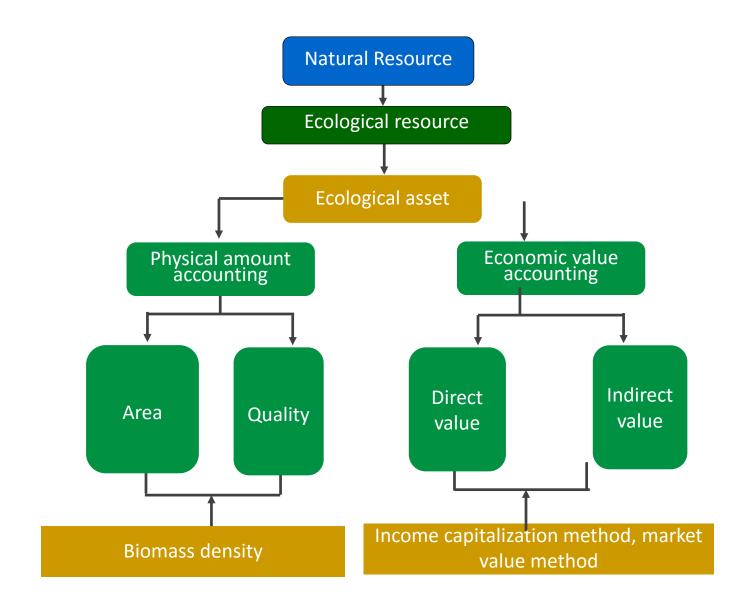
- Accounting of economic values of ecosystem goods and services
  - ✓ GEP: the total economic value of ecosystem provision (EPV), Ecosystem regulating services (ERV) and cultural services (ECV) in the given area annually.

$$GEP = EPV + ERV + ECV$$

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



### **Ecological asset accounting**



Types of	ΕΛc	Items of EA	Quality level (ha)						Dhysical value	
Types of	EAS	items of EA	Sum	I	=	Ш	IV	V	Physical value	
		Sub-sum								
	Forest	Coniferous F								
	roiest	Broadleaf F								
		Confe-Broadl F							Area, biomass density	
		Evergreen Shrub								
	Shrub	Coniferous shrub								
		Sub-sum								
Natural	Grassland	Meadow							Area, coverage	
ecosystem		Steppe								
		Sub-sum							_	
	Wetland	Lake							Area, water quality	
	vvetianu	Marsh							Area, water quality	
		River							Length, water quality	
		Sub-sum								
	Desert	Sand-land		_	_	_	_	_	Area	
	Desert	Rock		_	_	_	_	_	Alea	
		Bare land		_	_	_	_	_		



## **Ecological asset accounting**

Types of EAs		Items of EA	Quality level (ha)						Dhysical value	
Туре	S OI EAS	items of EA	Sum	I	II	Ш	IV	V	Physical value	
		Sub-sum								
		Dry cropland								
	Cropland	Paddy							Area, soil fertility	
		Orchard								
		Sub-sum								
Managed ecosystem	Artificial forest	Arti-Coniferous F							Area, biomass	
ceosystem		Arti-Broadleaf F								
	Artificial grassland	Arti-grassland							Area, coverage	
	Reservoir	Reservoir							Area, capacity, water quality	
	Urban green space	Urban green space							Area	

#### **Quality index of Ecological Asset**

$$EQ = \frac{\sum_{i=1}^{5} (EA_i \times i)}{(EA \times 5)} \times 100$$

- EQ: Quality index of Ecological Asset;
- EAi: area of i level ecosystem;
- i: level of ecological asset, ie 1 or 2,...5;
- EA: Total area of ecosystems.



## Pilot study of GEP accounting

#### **Pilot GEP accounting in China**

- China government agencies: National development and reform committee (NDRC), Environmental protection ministry (MEP), State forestry administrative (SFA), and SAC are pushing GEP accounting application in China.
- ♦ MEP supported Technical Guideline of GEP Accounting and training courses.
- Asian Development Bank(ADB): funded TA project "Developing Gross Ecosystem Product Accounting for Eco-Compensation" to pushing GEP

application in China

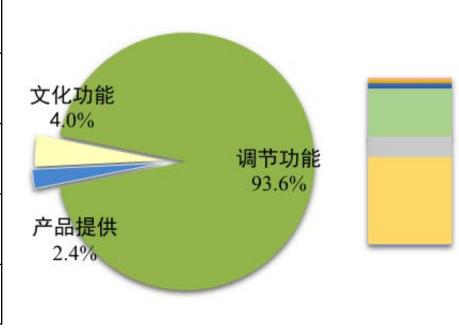
- ♦ Local government in China: 16 pilots
  - Qinghai, Guizhou,
  - Shenzhen, Tonghua, Qiandongna
  - Aershan, Xishui, Pingbian, Eshan





#### GEP in Qinghai: 18789.69 亿元

Items	Value(billion)	Ratio(%)
Provision services	45.38	2.4
Regulating services	1759.18	93.6
Cultural service	74.41	4.0
合 计	1878.97	100.0





Regulating service value in Qinghai Province

Service ditems 2	Index?	Biophysical2 value2	Unit?	Economic? value(billion)?	Total(billion) 2
Water2 retention2	水源涵养量⑵	638.722	10 <sup>8</sup> m <sup>3</sup> ?	510.342	510.342
	减少泥沙淤积ឱ	3.912	10 <sup>8</sup> m <sup>3</sup> 2	6.892	
Soil@retention@	减少 N 面源污染②	0.082	10 <sup>8</sup> t?	7.29?	20.992
	减少 P 面源污染②	value   va			
Sandafixation?	固沙量?	11.74?	10 <sup>8</sup> t?	33.127	33.12?
	湖泊调蓄量②	48.042	10 <sup>8</sup> m <sup>3</sup> 2	38.39?	
Flood2 mitigation2	水库调蓄量②	11.602	10 <sup>8</sup> m <sup>3</sup> 2	9.272	59.932
miligations	沼泽调蓄量②	15.36?	value?         Unit?         value(billion)?         10ta           638.72?         108m³?         510.34?         52           3.91?         108m³?         6.89?         0.08?         0.08t?         7.29?         2           0.02?         108t?         6.81?         33.12?         3           11.74?         108t?         33.12?         3           48.04?         108m³?         38.39?         5           11.60?         108m³?         9.27?         5           15.36?         108m³?         12.27?         5           93.63?         104t?         0.59?         0.59?           4.92?         104t?         0.03?         0           2.11?         104t?         0.01?         0           220.39?         104t?         0.15?         2           17.08?         104t?         0.48?         0           0.2567?         108t?         9.75?         2           2.6933?         108t?         195.81?         2           6534.60?         108kwh?         346.33?         9.2           0782.81?         108kwh?         571.49?         2           0.29?         108mu?         8.		
	净化 SO₂量〖	93.632	10 <sup>4</sup> t?	0.592	
Air@pollutant2	净化氮氧化物量②	4.922	10 <sup>4</sup> t?	0.032	0.622
purmeation	净化工业粉尘量2	value   val			
Water?	净化 COD 量?	220.39?	10 <sup>4</sup> t?	1.542	
pollutant2	净化总氮量②	17.082	10 <sup>4</sup> t?	0.152	2.172
purification?	净化总磷量②	17.082	10 <sup>4</sup> t?	0.482	
Carbon?	固碳量?	0.25672	10 <sup>8</sup> t?	9.752	205 509
sequestration®	释氧量②	10 <sup>8</sup> t回   10 <sup>8</sup> t回   7.29回   10 <sup>8</sup> t回   0.02回   10 <sup>8</sup> t回   6.81回   11.74回   10 <sup>8</sup> t回   33.12回   11.74回   10 <sup>8</sup> m³回   38.39回   11.60回   10 <sup>8</sup> m³回   9.27回   11.60回   10 <sup>8</sup> m³回   9.27回   12.27回   10 <sup>8</sup> m³回   12.27回   10.03回   10 <sup>8</sup> t回   0.03回   10.03回   10 <sup>8</sup> t回   0.01回   10.03回   10 <sup>8</sup> t回   1.54回   10.15回   10 <sup>8</sup> m³回   10 <sup>8</sup> m³回   10.15回   10 <sup>8</sup> m³回   10 <sup>8</sup> m³回   10.15回   10 <sup>8</sup> m³回   10.15回   10 <sup>8</sup> m³回   10.15回   10 <sup>8</sup> m³回   10.15回   10 <sup>8</sup> m³回   10 <sup>8</sup> m³回	205.562		
Climate2	植被蒸腾降温增湿②	6534.602	10 <sup>8</sup> kwh🛚	346.332	017 025
regulating?	水面蒸发降温增湿②	10782.812	10 <sup>8</sup> kwh?	571.49?	917.822
Pest@control2	森林病虫害控制面积』	0.292	10 <sup>8</sup> mu2	8.562	8.562
	Total			1759.182	1759.182



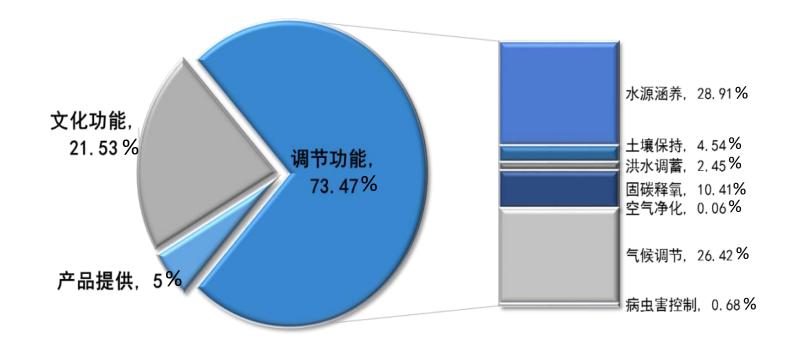
## GEP accounting of Qiandongnan, Guizhou

#### Qiandongnan GEP: 539.51 billion

Provision service: 27.0 billion, 5.0%

Regulating service: 396.35 billion, 73.5%;

Cultural service: 116.16 billion, 21.5%;





Regulating services value in Qiandongnan, Guizhou

Service items i	Index⊡	Biophysical <sup>®</sup> value <sup>®</sup>	Unit₪	Economic <sup>®</sup> value(billion)®	Total(billion) 🛭
Water@retention@	水源涵养量②	195.2222	10 <sup>8</sup> m <sup>3</sup> ?	155.981??	155.981???
	减少泥沙淤积ឱ	24.8443???	10 <sup>8</sup> m <sup>3</sup> ?	8.916??	
Soil@etention@	减少 N 面源污染®	24.8443???	10⁴t≀	8.043??	24.473???
	减少 P 面源亏染®	24.844322	10 <sup>4</sup> t?	7.513??	
Flood@mitigation@	湖泊调蓄量⑵	1.31252	10 <sup>8</sup> t⊡	0.014?	13.2272
Tioodamitigationa	水库调蓄量②	47.24902	10 <sup>8</sup> m <sup>3</sup> ?	13.213?	13.227
۵: سام مال سام م	净化 SO <sub>2</sub> 量®	45.27??	10 <sup>4</sup> m <sup>3</sup> ?	0.285??	
Air pollutant 2 purification 2	净化氮氧化物量②	1.71??	10 <sup>4</sup> m <sup>3</sup> ?	0.011??	0.298??
	净化工业粉尘量②	1.1722	10 <sup>4</sup> t?	0.002??	
?	净化 COD 量®	1.98??	10 <sup>4</sup> t?	0.014??	
Water₄pollutant?	净化总氮量②	0.1522	10 <sup>4</sup> t?	0.001??	0.019??
purification <sup>®</sup>	净化总磷量②	0.1522	10 <sup>4</sup> t?	0.004??	
Carbon?	固碳量?	0.1507??	10 <sup>4</sup> t⊡	5.727??	56.15122
sequestration?	释氧量?	0.693622	10 <sup>4</sup> t?	50.425??	30.131
	森林蒸腾降温增湿②	2235.2589	10 <sup>8</sup> t⊡	118.469???	
Climate?	<u>灌丛蒸腾降温增湿</u> ?	119.636622	10 <sup>8</sup> t⊡	6.341??	142.5232
regulating <sup>®</sup>	草地蒸腾降温增湿図	175.051822	10 <sup>8</sup> kwh2	9.278??	142.323
	水面蒸发降温增湿湿	159.170422	10 <sup>8</sup> kwh2	8.436??	
Pest@tontrol2	森林病虫害控制面积②	0.12252	10 <sup>8</sup> mu⊡	3.6752	3.6752
Total <sup>®</sup>	?	?	?	396.3472	396.3472



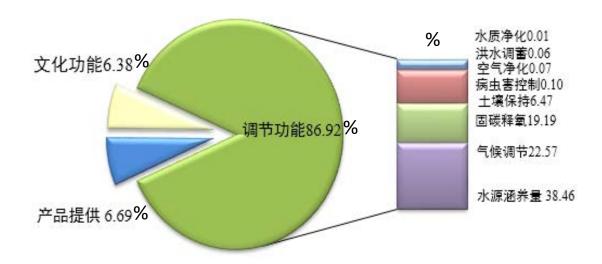
## GEP accounting of Pingbian county, Yunnan

#### GEP of Pingbian county: 20.77 billion

Provision service: 1.39 billion, 6.7%

Regulating service: 18.06 billion, 86.9%;

Cultural service: 1.33 billion, 6.4%;





## GEP accounting of Pingbian county, Yunnan

Regulating service in Pingbian county, Yunan

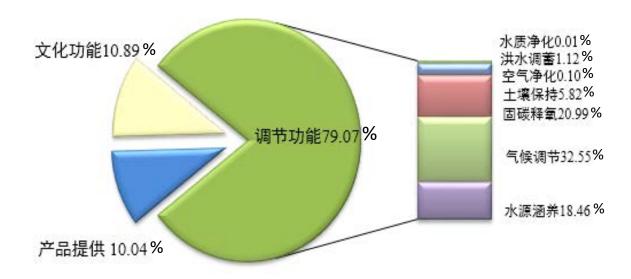
Service 1 tems 2	Index <sup>®</sup>	Biophysical? value?	Unit <sup>®</sup>	Economic2 value(billion)2	Total(billion)᠌
Water@tention@	水源涵养量②	9.99`?	10 <sup>8</sup> m <sup>3</sup> ?	7.992	7.992
	减少泥沙淤积ឱ	0.262	10 <sup>8</sup> m <sup>3</sup> ?	0.462	
Soil@retention@	减少 N 面源污染®	52.0?	10⁴t⊡	0.46?	1.342
	减少 P 面源污染②	15.02	10⁴t⊡	0.43?	
Flood@mitigation@	水库调蓄量®	0.042	10 <sup>8</sup> m <sup>3</sup> ?	0.0127	0.012
	净化 SO2 量🛭	2.32?	10⁴t⊡	0.0152	
Air@pollutant <sup>®</sup> purification <sup>®</sup>	净化氮氧化物量②	0.092	10 <sup>4</sup> t2	0.000552	0.0152
	净化工业粉尘量②	0.062	10⁴t⊡	0.000092	
	净化 COD 量®	0.082	10⁴t?	0.000542	
Waterpollutant  purification	净化总氮量②	0.01?	10⁴t⊡	0.000052	0.0012
·	净化总磷量®	0.01?	10⁴t⊡	0.000172	
Carbon <sup>®</sup>	固碳量2	0.00692	10 <sup>8</sup> t2	0.2652	3.99₪
sequestration <sup>2</sup>	释氧量?	0.05132	10 <sup>8</sup> t2	3.732?	3.99⊞
Climate <sup>®</sup>	植被蒸腾降温增湿②	84.622	10 <sup>8</sup> kwh?	4.532?	4.COG
regulating?	pollutant@ cation?       净化总氮量②       0.01②       10⁴tl         净化总磷量②       0.01②       10⁴tl         bon②       固碳量②       0.0069②       10²tl         stration②       释氧量②       0.0513②       10²tl         nate②       植被蒸腾降温增湿②       84.62②       10²kwh	10 <sup>8</sup> kwh?	0.1582	4.69🛚	
Pest@control <sup>®</sup>	森林病虫害控制面积®	0.00072	10 <sup>8</sup> mu2	0.0217	0.027
Total?	?	?	?	18.062	18.062



## GEP accounting of Eshan county, Yunnan

#### GEP of Eshan county: 8.80 billion

- Provision service: 1.89 billion, 10.0%
- Regulating service: 14.86 billion, 79.1%;
- Cultural service: 2.05 billion, 10.9%;





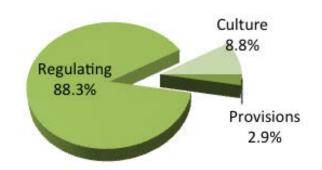
## GEP accounting of Eshan county, Yunnan

Regulating service in Eshan county, Yunan

Service 1 tems 2	Index₪	Biophysical? value?	Unit <sup>®</sup>	Economic <sup>®</sup> value(billion)®	Total(billion)
Water <sup>®</sup> retention <sup>®</sup>	水源涵养量②	4.342	10 <sup>8</sup> m32	3.471?	3.471?
	减少泥沙淤积ឱ	0.21472	10 <sup>8</sup> m3?	0.3792	
Soil@retention@	减少 N 面源污染②	42.02	10 <sup>4</sup> t?	0.3702	1.0942
	减少 P 面源污染②	12.02	10 <sup>4</sup> t?	0.3452	
Flood? mitigation?	水库调蓄量⑵	0.762	10 <sup>8</sup> m32	0.2112	0.2112
	净化 SO2 量®	2.94?	10 <sup>4</sup> t?	0.0182	
Air  purification  ?	净化氮氧化物量②	0.112	10 <sup>4</sup> t?	0.0012	0.0192
F	净化工业粉尘量②	0.072	10 <sup>4</sup> t?	0.00012	
Water?	净化 COD 量②	0.182	10 <sup>4</sup> t?	0.0012	
pollutant2	净化总氮量②	0.01?	10 <sup>4</sup> t?	0.000082	0.0022
purification?	净化总磷量⑵	0.012	10 <sup>4</sup> t?	0.000282	
Carbon <sup></sup>	固碳量②	0.00552	10 <sup>8</sup> t?	0.2092	2.0458
sequestration <sup>®</sup>	释氧量②	0.05142	10 <sup>8</sup> t?	3.7362	3.9452
Climate <sup>[]</sup>	植被蒸腾降温增湿②	105.452	10 <sup>8</sup> kwh?	5.5882	C 1100
regulating₪	水面蒸发降温增湿〗	10.012	10 <sup>8</sup> kwh🏾	0.5302	6.1192
Pest@control2	森林病虫害控制面积②	0.00012	10 <sup>8</sup> mu?	0.0032	0.0032
Total2	?	?	?	14.8642	14.8642

## GEP accounting of Aershan

#### 2014



Services	Value (billion Yuan)	Percenatage
Provisions	1.529	2.9%
Regulating	47.255	88.3%
Culture	4.710	8.8%
Sum	53.494	100%

Services	Items	Index	Bio-physical value	Units	Price	Monetary value	%	Sub-sum 亿元	%
		Agricultural products	8.70	x 10 <sup>4</sup> tons	- 82	1.59	0.30		
		Forestry products				0.11	0.02		
		Husbandry products			32	1.14	0.21		
Provision	Agricultural products	15.29	2.86						
Provision Production  Wareter Soil ret Sandst Floo A Purific Carl seques Clim regul Pest c		Water resource	1333.74	x 10 <sup>4</sup> tons		2.15	0.40		
		Other			82	10.00	1.87		
		Amount of Water retention	8.19	x 10 <sup>H</sup> m <sup>3</sup>	7.63yuan/m³	62.53	11.69	62.53	11.69
		Reduce sediments	0.2078	x 10 <sup>H</sup> m <sup>3</sup>	16.84yuan/t	3.50	0.65	11.91	2.23
	Soil retention	Reduce N loading	0.0038	x 10 <sup>8</sup> tons	1500yuan/t	5.66	1.06		
		Reduce P loading	0.0011	x 10 <sup>8</sup> tons	2500yuan/t	2.75	0.51		
	Sandstorm P	Amount of sand F	0.0285	x 10 <sup>8</sup> tons	37500yuan/km²	0.91	0.17	0.91	0.17
	Flood M	Flood mitigated in lakes	0.26	x 10 <sup>H</sup> m <sup>3</sup>	7.63yuan/m³	1.97	0.37	49.00	9.14
		Flood mitigated in marsh	6.15	x 10 <sup>8</sup> m <sup>3</sup>	7.63yuan/m³	46.93	8.77	40.30	3.14
		SO2 purification	0.1410	x 10 <sup>9</sup> m <sup>3</sup>	1550yuan/t	0.02	0.00		
	D 10 11	NOx purification	0.0445	x 10 <sup>4</sup> tons	810 yuan/t	0.00	0.00	0.03	0.01
Regulating	rumcation	Dust purification	0.2298	x 10 <sup>4</sup> tons	190 yuan/t	0.00	0.00		
	***	COD purification	0.1340	x 10 <sup>4</sup> tons	700 yuan/t	0.01	0.00		0.00
Regulating	217777	Total N purification	0.0096	x 10 <sup>4</sup> tons	1500 yuan/t	0.00	0.00	62.53 11.91 0.91 48.90 0.03	
	purmeation	Total P purification	0.0010	x 10 <sup>4</sup> tons	2500 yuan/t	0.00	0.00		
	Carbon	Carbon sequestration	0.0631	x 10 <sup>4</sup> tons	312 yuan/t	19.70	3.68	122 20	24.93
	sequestration	Oxygen release	0.1137	x 10 <sup>8</sup> tons	1000 yuan/t	113.67	21.25	133.30	
		Heat absorbed by forest	211.80	x 10 <sup>8</sup> kwh	0.49 yuan	103.78	19.40		
	Climate	Heat absorbed by shrubs	4.60	x 10" kwh	0.49 yuan	2.25	0.42	212.80	39.80
	regulating	Heat absorbed by grassland	8.39	x 10 <sup>8</sup> kwh	0.49 yuan	4.11	0.77	212.03	33.00
		Heat absorbed by wetland	209.69	x 10 <sup>8</sup> kwh	0.49 yuan	102.75	19.21		
	Pest control	Pest confront in forests	53.33	X 10 <sup>4</sup> ha	375 yuan/ha	2.00	0.37	2.00	0.37
Culture	Landscape	Tourism in landscape				47.10	8.80	47.10	8.80



- ✓ More case studies at different administrative regions: provinces cities, and counties.
- ✓ Prepare national standard for GEP accounting supported by SAC.
- ✓ GEP in policy applications, such as PES, evaluation system of local government performance beyond GDP.
- ✓ Index for monitoring progresses of ecological civilization and sustainability.

