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"Research on opportunities of using GEP in Mongolia: Methodology and a case study of Khovd province"

Abstract:

The valuation of ecosystem products (services) is an effective method for measuring the connections between ecosystem assets and humans. Gross Ecosystem Product (GEP) is the total monetary value of final ecosystem goods and services supplied to human well-being in a given region annually, like a country, a province, or a county. Gross Ecosystem Product (GEP) is the monetary value of ecosystem services, making the findings comparable to GDP. GEP can reflect the ecosystem's contribution to human well-being.

The general purpose of this study is to analyze the theoretical and empirical application of Gross Ecosystem Product (GEP), to explore opportunities for using it, and to calculate GEP in selected cases in Mongolia. It is the first study to focus on ecosystem economic value and to introduce Gross ecosystem product (GEP) accounting, and its application in Mongolia.

From the theoretical side, the study as a whole would enrich the literature related to using economic valuation methods for ecosystem value and environmental amenities, and introduce a new valuation method in our country. Monetary values for ecosystem valuation do not fully reflect the importance of ecosystems for people and the economy. Using GEP, we will contribute fill up gaps in theoretical research.

From the practical side, the study is expected to add new knowledge to the existing empirical literature on ecosystem value and to introduce a new application (GEP) for ecosystem value, as there is no systematic research for calculating ecosystem goods and services supplied to human well-being in a given region annually.

Thus, the study could be a base for designing and choosing appropriate economic valuation methods for ecosystem goods and services in my country. This research is not only to study that defining possibilities of GEP's application, but also as finding appropriate methods together with technical and economical evaluations. Furthermore, the study could provide a reference for ecosystem management and development planning in my country.

There are 3 parts to GEP accounting. We will identify and examine categories and indicators for each part of GEP for Khovd province chosen as a case of our study in Mongolia.

Key words:

Valuation of ecosystem products, ecosystem goods and services, ecosystem valuation, gross ecosystem product, ecosystem product accounting indicators

The major challenge of the 21st century is to develop economic, social, and governance systems capable of ending poverty and achieving sustainable levels of population and consumption while securing the life-support systems underpinning current and future human well-being. With the development of economic and human society, severe environmental issues including climate change, land degradation, air pollution, water pollution, and biodiversity loss have emerged and brought huge damage to people all over the world.

Nowadays theoretical and empirical researches are increasingly important in environmental studies. Both theoretical and empirical types of research concerning environmental assessment are extremely important to guarantee environment assessment and restoration. Consequently, we have been conducting a comprehensive, multilevel, and multi-dimensional analysis on the current state and evolving of studies in environmental assessment.

Environmental economics, combined with other social and behavioral sciences, is crucial for understanding how it might be possible to shift human behavior toward achieving sustainable development. Sustainable development refers to the development that could satisfy the demands of current generations but without harm to the following generations' ability to satisfy their demands. The application of environmental economic and empirical findings should be a central component in the quest to meet the aspirations of humanity for a good life given the finite resources of the earth.

In 1997, Robert Costanza was the first to estimate the worldwide worth of ecosystem services-bringing new attention to the field of ecosystem valuation. three decades later, the World Bank, that "the benefits provided by natural ecosystems are both widely recognized and poorly understood.

Citing the importance of such knowledge to informed policy-making, in 2007, Environmental Ministers from the "G8+5" nations agreed to both publicly call for and begin to undertake the calculation of global ecosystem benefits, conservation costs, and the opportunity costs of developing such ecosystems.

In the USA, the President's Council on Science and Technology suggested in 2011 that the "U.S. government should institute and fund a Quadrennial Ecosystems Services Trends (QuEST) Assessment" that studying trends in ecosystem performance, quality, and value.

Guoxia Ma et.al (2000) presented that framework construction and application of China's Gross Economic-Ecological Product accounting, and they calculated GEEP based on the GDP of the economic system, meanwhile considering the damage to the ecological environment and the ecological benefit.

In February 2013, China launched the gross ecosystem product (GEP) accounting project (United Nations, 2013), which measured the final output value of a certain regional ecosystem for economic and other human activities in a specific period. It provides an important reference for quantifying the ability of natural resource to provide ecosystem service and their contribution to human well-being. In the same year, China first proposed exploring the compilation of NRBS (Natural resource balance sheet) and proposed auditing departing leaders for eco-environmental responsibility (Song et al., 2019).

In September 2020, the first version of the technical guideline on Gross Ecosystem Product (GEP) was issued by The Chinese Academy of Environmental Planning and Research Center for Eco-Environmental Sciences, CAS. Nowadays, there are about 200 experts and researchers conducting research which is related to this field.

In 2015, 195 nations agreed with the United Nation that they can change the world for the better. Mongolia is of the first countries to adopt Sustainable Development Goals 2030 Agenda, and our country joined the UN and their SDGs to help.

Nowadays we are facing environmental challenges that are caused by both human activities and natural factors such as climate change, deforestation, desertification and land degradation, pollution, loss of biodiversity in Mongolia. These factors lead to eco-environmental degradation and damage caused by such as mining, resource depletion, agricultural pollution, overpopulation, landfill, deforestation and desertification etc.

Mongolia, focusing on legislation for ecosystem value, in the context of economic value and welfare impacts, using such as approach using qualitative document analysis, empirical and case study research approach. The general purpose of this study is to analyze theoretical and empirically application of Gross Ecosystem Product, to explore opportunities of using it, and to calculate GEP in selected cases in Mongolia, focusing on legislation for ecosystem value, in the context of economic value and welfare impacts, using such as approach using qualitative document analysis, empirical and case study research approach.

Why we should use GEP?

Ecosystem products and services are essentials for human survival and development. Gross Ecosystem Product (GEP) aims to specific indicators to measure the total economic value of all ecosystem products and services. Ecosystems that can be measured include natural ecosystems such as forests, grassland, wetland, desert, freshwater and ocean, and artificial systems that are based on natural processes like farmland, pastures, aquaculture farms and urban green land, etc.

GEP is the total value of final ecosystem goods and services supplied to human well-being in a region annually, and can be measured in terms of biophysical value and monetary value. GEP accounting can reflect the impact of human activities on the ecosystem and quantitatively reflect the role of ecosystems in economic development, so as to achieve the coordinated development of economic society and ecological civilization.

Which is more important ? GDP, Green GDP, or GEP?

Not knowing the economic value of a resource can lead to the detriment and depletion of ecosystem services. As a consequence, the "ecosystem service approach" is becoming more and more widely accepted at both academic and policy levels.

How and which factors are required for calculation?

GEP is the addition of the total economic value of ecosystem provision (EPS), Ecosystem regulating services (ERS) and cultural services (ECV) in the given area annually.

GEP=EPV+ERS+ECS (1)

After calculating the GEP of the province which is selected, then it is compared with its GDP.

GEP accounting methods and indicators

The accounting indicator system for ecosystem gross domestic product consists of material products, regulatory services, and cultural services, among which: material products mainly include agricultural products, forestry products, animal husbandry products, fishery products, ecological energy, and others; Regulation services mainly include water source conservation, soil conservation, wind and sand fixation, coastal zone protection, flood regulation and storage, carbon fixation, oxygen supply, air purification, water quality purification, climate regulation, and species conservation; Cultural services mainly include leisure tourism and landscape value, as shown in Tables 1 and 2.

Table 1. Gross Ecosystem Product (GEP) Accounting Indicators

№	First-level indicators	Second-level indicators	Description of indicators
1	Ecosystem material product	Agricultural production	Primary products obtained from agricultural ecosystems, such as rice, corn, millet, beans, potatoes, oilseeds, cotton, hemp, sugar, tobacco, tea, medicinal materials, vegetables, fruits, etc.
2		Forestry production	Forest products, forestry and primary products related to forest resources, such as wood, bamboo, turpentine, raw lacquer, tung seeds, etc.
3		Animal husbandry production	Products obtained by raising livestock, such as cattle, sheep, pigs, poultry, milk, eggs, etc., by means of grazing, captivity or a combination of the two.
4		Fishery production	Aquatic products, such as fish and other aquatic animals, obtained by means of fishing and aquaculture by using the material transformation function of organisms in the water area.
5		Ecological energy	Biomass in the ecosystem and its energy, such as biogas, straw, firewood, water energy, etc.
6		Others	Some products used for decoration (such as animal fur) and flowers, seedlings, etc.
7	Regulating services	Water conservation	Through its structure and process, ecosystem can intercept and store precipitation, enhance soil infiltration, conserve soil water, supplement groundwater, regulate river flow, and increase the amount of available water resources.
8		Soil conservation	Ecosystem functions through its structure and processes to protect soil, reduce the erosive capacity of rainwater, and reduce soil loss.
9		Windbreak and sand fixation	Ecosystem functions by increasing soil wind resistance and reducing wind erosion and sand damage.
10		Coastal protection	The function of ecosystems to reduce waves and avoid or reduce seawall or coastal erosion.
11		flood regulation	The function of ecosystems to reduce flood damage by regulating storm runoff and reducing flood peaks.
12		Carbon fixation	Ecosystems absorb carbon dioxide to synthesize organic matter, fix carbon in plants and soil, and reduce the concentration of carbon dioxide in the atmosphere.
13		Oxygen supply	Ecosystems release oxygen through photosynthesis to maintain a stable atmospheric oxygen concentration.
14		Air purification	The ecosystem absorbs and blocks pollutants in the atmosphere, such as SO2, NOx, particulate matter, etc., reduces the concentration of air pollution, and improves the function of the air environment.
15		water purification	The ecosystem functions to reduce the concentration of water pollutants and purify the water environment through the adsorption, degradation and biological absorption of water pollutants through physical and biochemical processes.
16		Climate regulation	Ecosystem absorbs energy, lowers air temperature, and increases humidity through vegetation transpiration and water surface evaporation.
17		Species conservation	The role and value of ecosystems in providing survival and reproduction sites for rare and endangered species.
18	Cultural services	Leisure Travel	The non-material benefits that humans obtain from the ecosystem through tourism and leisure methods such as spiritual feelings, knowledge acquisition, leisure and aesthetic experience, and health care.
19		landscape value	Ecosystems provide human beings with aesthetic experience and spiritual pleasure, thereby enhancing the function of surrounding land and property values.

Table 2. Ecosystem Gross Product Physical Quantity and Value Calculation Index System

Category of ecosystem services	Accounting subject	Physical Quantity Indicator	Value indicator
Material product	Agricultural production	Agricultural product output	Output value of agricultural product output
	Forestry production	Forestry product output	Output value of forestry product output
	Animal husbandry production	Animal husbandry product output	Output value of animal husbandry product output
	Fishery production	Fishery product output	Output value of fishery products
	Ecological energy	Total ecological energy	Output value of eco-energy
	Others	The total amount of decorative ornamental resources	Output value of decorative ornamental resources, etc.
Regulating services	Water conservation	Water conservation	Water conservation value
	Soil conservation	Soil retention	Reduce the value of sediment deposition
			Reduce the value of non-point source pollution
	Windbreak and sand fixation	Sand fixation	Grass Restoration Costs
	Coastal protection	Coastal protection area	Coastal protection value
	Flood regulation	Flood regulation and storage capacity	Flood regulation and storage value
	Air purification	Purified sulfur dioxide	Purification of sulfur dioxide value
		The amount of nitrogen oxides purified	Purifying nitrogen oxides value
		The amount of purified particulate matter	Clean particulate matter value
	Water purification	Purified COD amount	Purify COD value
		Purified total nitrogen	Purified total nitrogen value
		Purified total phosphorus	Purified total phosphorus value
	carbon fixation	Fixed amount of carbon dioxide	Carbon fixed value
	oxygen supply	Oxygen supply	Oxygen provides value
	Climate regulation	Energy consumption of vegetation transpiration	Value of vegetation transpiration in regulating temperature and humidity
		Water surface evaporation consumes energy	Value of water surface evaporation in regulating temperature and humidity
	Species conservation	Number of rare and endangered species and area of reserve	Conservation value of rare and endangered species reserve
Cultural services	Leisure Travel	Total number of tourists	Recreation and wellness value
	landscape value	Beneficial land and property area	Appreciation of land and real estate

Table 3. GEP accounting index and methods (Khovd, Mongolia)

Types of service	Category of ecosystem services	Accounting items	Biophysical value accounting methods	Using Values	Valuation method	Data source (2000-2020)
Ecosystem material services (EMV)	Production of ecosystem goods	Agricultural crop production Animal husbandry production Fishery production Forestry production Plant nursery production	$E_{pro} = \sum_{i=1}^{n} Y_i$ Where, E*pro* is the total yield of ecosystem products, Yi is he yield of the i-th product , n is the products category	Market price	***Market valuation method:*** $V_m = \sum_{i=1}^{n} Y_i * P_i$ Where, Yi is the monetary value of material services (MNT) , Pi is the price category I ecosystem products (MNT)	The annual yield for products are reported in the Khovd statistical yearbook, in the report of Agricultural Department
	Water supply	Water use in downstream agricultural irrigation Water use in households Water use in industry Hydropower production	**SWAT model**: $NS = 1 - \frac{\sum_i (Q_m - Q_s)_i^2}{\sum_i (Q_{m,i} - \bar{Q}_m)^2}$ Where Q is a variable (e.g., discharge), and m and s stand for measured and simulated data points, respectively. The bar stands for average	Market prices for water Market prices for electricity	***Shadow engineering method:*** $V_{wr} = C_{wt} * c_{wr}$ Where, Yw represents the accounting value of water retention (MNT/year) , c*wr* is the average cost of reservoir construction, C_{wt} represents the water retention capacity	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia There is Durgun hydro-electric station in Khovd province.

Regulating services	Flood mitigation	Flood mitigation	The flood mitigated service provided by ecosystems includes runoff retention by vegetation and runoff retention by lakes. $$C_{fm} = C_{vc} + C_{lc}$$ Where C_{fm} is the total storage of flood water (m^3), C_{vc} is the storage of flood water from natural vegetation (m^3), C_{lc} is the storage of flood water by lakes (rivers) (m^3). $$C_{vc} = \sum_{i=1}^{j} (P_{fi} - R_{fi}) * A_i * 1000$$ Where P_{fi} is the average annual storm rainfall (mm), R_{fi} is the stormwater runoff (mm), A_i is the area of i-type ecosystem (m^2), i is the type of ecosystem in the study area, j is the total number of ecosystem types in the study area. $$\ln(C_{lc}) = 0.927 \ln(A) + 4.904$$ Where A is the lake (rver) area.	Avoided water storage costs	***Shadow project method:*** $$V_{fm} = C_{fm} + C_{wc}$$ Where V_{fm} represents the accounting value of flood mitigation (MNT/year), C_{wc} is the average cost of reservoir construction.	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia

	Soil retention and nonpoint pollution prevention	Retained soil, N, and P	Universal soil loss equation (USLE) $Q_{sr} = R * K * LS * (1 - C * P)$ Where Qrs represents the soil retention capacity, R is the rainfall erosivity factor, K is the soil erodibility factor, LS the topographic factor representing the effect of the length of slope, C is the the vegetation cover factor, and P is the practice factors of soil erosion control	Avoided treatment costs	***Replacement cost method:*** $V_{sr} = V_{sd} + V_{dpd}$ Where, Ysr represents the accounting value of soil retention (MNT/year), V*sd* is the reduced cost of dredging (MNT/year), V*dpd* the the reduced cost of non-point source pollution treatment (MNT/year). $V_{sd} = \lambda * \left({}^{Q_{sr}}/_{\rho}\right) * c$ Where λ is the sediment deposition coefficient, ρ is the soil bulk density (t/m^3), c is the cost of reservoir dredgingper unit (MNT/m^3). $V_{dpd} = \sum_{i=1}^{2} Q_{sr} * C_i * p_i$ Where Ci is the content of N and P in sediment, pi is the cost of to treat waste water of nitrogen and phos-phorus (MNT/t)	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia

	Water purification (wetland)	Purification	$C_{wp} = \sum_{i=1}^{n} Q_i * A$ Where Cwp represents ecosystem water purification capacity (kg a^{-1}), Qi is the purification amount per unit area of type i water pollutants [42-44], i is the pollutant category, A is the wetland area (km^2)		We used water treatment costs for removing COD, ammonia nitrogen and total phosphorus to assess the accounting value of the water purification service. $V_{wp} = \sum_{i=1}^{n} Q_i * c_i$ Where c_i is the unit treatment cost of type i water pollutant (MNT/t).	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia
	Air purification	Purification	$C_{ap} = \sum_{i=1}^{m} \sum_{j=1}^{n} Q_{ij} A_i$ Where C*ap* is the ecosystem air purification capacity (kg a^{-1}), Q_{ij} is the purification amount per unit area of the jth air pollutant in the i type ecosystem (kg km^{-2} a^{-1}), Ai is the area of type i ecosystem (km^2).	1. V TP&WT A 2. A voided air filtration costs	1. ***Contingent valuation method***: 2. We used ***the treatment cost of reducing air pollution*** to calculate the accounting value of air purification from vegetation. $V_{ap} = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} * c_j$ Where C_{ij} is the purification amount of the jth air pollutant in the i type ecosystem (kg a^{-1}), c_j is the cost of treating j-type air pollutants.	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia

	Sandstorm prevention	Purification	REWQ model	1. Avoided health costs 2. TP&WTA	1. Recovery Expense Method 2. ***Contingent valuation method***:	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia
	Carbon sequestration	Purification	We examined the dynamics of biomass carbon storage in ecosystems and estimated the average annual carbon sequestration of ecosystems. $Q_{cs} = \frac{M_{CO_2}}{M_C} * A * C * (AGB_{t2} - AGB_{t1})$ Where Qcs is the amount of carbon sequestration in ecosystems (tCO_2/y), A is the ecosystem area (km^2), C_C is the biomass-carbon conversion coefficient, AGB_{t2} and AGB_{t1} are the biomass levels at t_2 and t_1 years (t/km^2), M_{CO2}/M_C=44/12 is the coefficient for C to CO_2 .	Afforestation cost	We set price equal to the cost of sequestering carbon via afforestation or reductions in industrial emissions. $V_{cs} = Q_{cs} * C_C$ Where C_C is the afforestation cost (MNT/tCO_2) [46].	State of the Environment Report , Mongolia Statistikal year book of Khovd province, and Mongolia

	Climate regulation		The climate regulation service provided by ecosystems includes temperature retention by vegetation transpiration and temperature retention by water surface evaporation . $E_{cr} = E_{pt} + E_{we}$ $E_{pt} = \sum_{i}^{3} EPP_i * A_i * D * \frac{10^6}{3600 * r}$ $E_{we} = E_w * q * 10^3/(3600)$ Where Ecr represents energy consumed by ecosystems to regulate climate (kwh), Ept is the energy consumed by ecosystem transpiration (kwh), Ewe is the energy consumed by ecosystem water evaporation (kwh), EPPi is the energy consumption per unit area of i-type ecosystem, Ai is the area of i-type ecosystem (km2), r is the air conditioning energy efficiency ratio: 3.0, D is the number of days the air conditioner is operated (d), i is the type of ecosystem (forest, shrub, grassland), Ew is the amount of water surface evaporation, q is the evaporation latent heat of water (J/g).		***Replacement cost method:*** The accounting value of climate regulation can be assessed using the power consumption required for artificial temperature adjustment (kwh), measured by electricity price (MNT/kwh). $V_{cr} = E_{cr} * P_e$ Where Pe is the residential electricity price (MNT/kwh).	1.Energy regulatory commission of Mogolia State of the 3. Environment Report , Mongolia 4. Household socio-economic survey
Ecosystem cultural services	Ecotourism	Tourists and related costs	Questionnaire surveys	Travel expend itures	Travel cost method (Zone TCM)	Khar-Us National Park, 3 Senkher Agui, and others were identified as a representative sample point for questionnaire surveys . The number of tourists that visited Khovd province was determined based on official statistics kept by Khovd province .

Conclusions and recommendations

The general purpose of this study is to analyze theoretical and empirically application of Gross Ecosystem Product, to explore opportunities of using it, and to calculate GEP in selected cases in Mongolia, focusing on legislation for ecosystem value, in the context of economic value and welfare impacts, using such as approach using qualitative document analysis, empirical and case study research approach.

It is the first study to focus on ecosystem economic value and to introduce Gross ecosystem product (GEP) accounting, its application in Mongolia. From the theoretical side, the study as a whole would enrich the literature related to using economic valuation methods for ecosystem value and environmental amenity, and introduce a new valuation method in our country. Furthermore, the thesis will try to explore the possibilities of using GEP in Mongolia and to build a theoretical framework of ecosystem value and its socio-economic impacts on welfare. Monetary values for ecosystem valuation do not fully reflect the importance of ecosystems for people and the economy. Using GEP, we will contribute fill up gaps in theoretical research.

From the practical side, the study is expected to add new knowledge to the existing empirical literature on ecosystem value and to introduce new application (GEP) for ecosystem value, as there is no systematic research for calculating ecosystem goods and services supplied to human well-being in given region annually. Thus, the study could be a base for designing and choosing appropriate economic valuation methods for ecosystem goods and service in my country. This research not only to study that defining possibilities of GEP's application, but also as finding appropriate methods together with technical and economical evaluations. Furthermore, the study could provide a reference for ecosystem management and development planning in my country.

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