

全面深化改革中的经济与金融研讨会



西安交通大学 经济与金融学院

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Natural resources balance sheet: concept, accounting framework, and case study

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Foundation

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Background

1 Introduction

■ Background

■ Policy

2 Literature Review

■ SNA, SEEA and natural resources accounting

■ Ecological liability, environmental liability and natural resource liability

■ Natural resources balance sheet

3 Methodology

■ Accounting framework

■ Key accounting concepts

■ Compilation steps

4 Case Study

■ Study area

■ Data resources and monetary methods

■ NRBS Accounting in Shaanxi province

5 Conclusion

Natural resources consumption

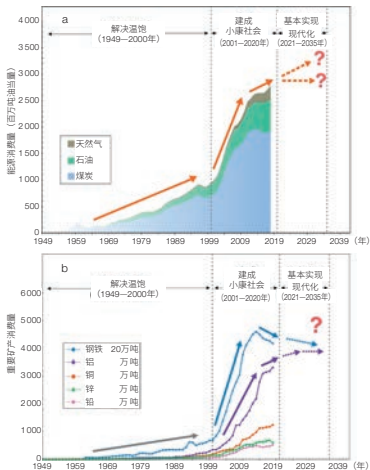


图1 中国能源 (a) 和重要矿产 (b) 资源需求增长趋势

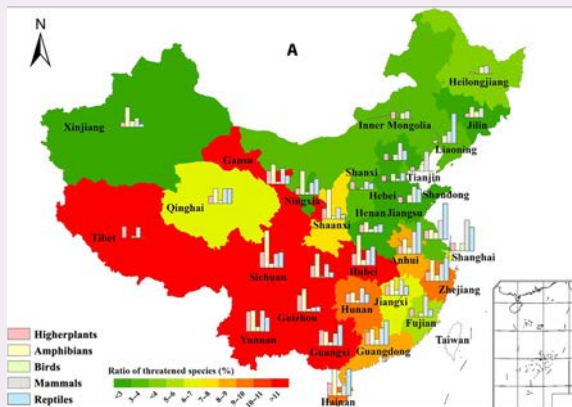
China's consumption of energy and important mineral resources has been 2-8 times that of the 50 years since 1949 (Wang and Gao, 2020)

Environmental destruction



City besieged by waste, decline of the water table, and suspended particles emission (Shen et al., 2017)

Biodiversity loss



(Lu et al., 2020)

Global Warming



(Shan et al., 2017, 2020)

1 Introduction

■ Background

■ Policy

2 Literature Review

■ SNA, SEEA and natural resources accounting

■ Ecological liability, environmental liability and natural resource liability

■ Natural resources balance sheet

3 Methodology

■ Accounting framework

■ Key accounting concepts

■ Compilation steps

4 Case Study

■ Study area

■ Data resources and monetary methods

■ NRBS Accounting in Shaanxi province

5 Conclusion

Third Session of 18th Communist Party of China National Congress

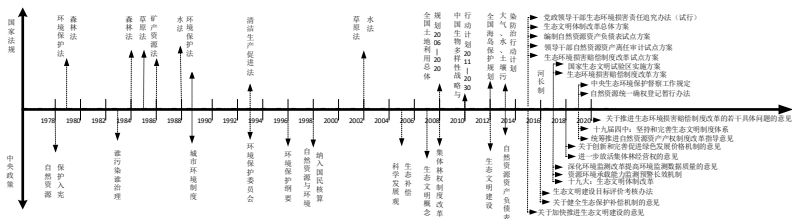


Chinese government has proposed to establish natural resources balance sheet (NRBS) and to set up the pilot scheme in selected regions (Feng et al., 2014)

Huzhou, Zhejiang



Lucid water and lush mountains are invaluable assets (Ouyang et al., 2020).



- Guidance on the Integrated Reform of Property Rights Regimes of Natural Resource Assets
- Interim Measures for the Unified Confirmation and Registration of Natural Resources

How to compile NRBS ?

- Natural resources assets
- Natural resources liabilities
- Owner's equity
- Affix responsibility of the liability
- Departure Audit System for Leading Cadres

SNA, SEEA and natural resources accounting

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

SNA, SEEA and natural resources accounting

UN: System of National Accounts, 1953

- Four fundamental principles: economic units, production, recording of transactions and assets.
- Gross domestic product (GDP) provides an economic snapshot of a country.

Limitations

- Ignore the using up of natural resource stocks (Hartwick, 1990)
- Misuse in measuring of welfare (Costanza et al. 2009)
- The over-exploitation of natural resources and the emissions of pollutants are typically included within the family of negative 'externalities', which do not find a place within the SNA (La Notte and Rhodesb, 2020).
- Lacking of the production boundary are widely known that the limitations of its ability to describe the linkages between economic and environmental system (Eigenraam and Obst, 2018)

SNA, SEEA and natural resources accounting

UN: System of Environmental Economic Accounting, 1993

- Systematically evaluating for environmental resource stocks and capital flows.
- Including: flows of materials and energy in physical terms, stocks of environmental assets, and environmental related transactions (La Notte and Rhodesb, 2020)

SNA, SEEA and natural resources accounting

The relationship between SNA and SEEA.

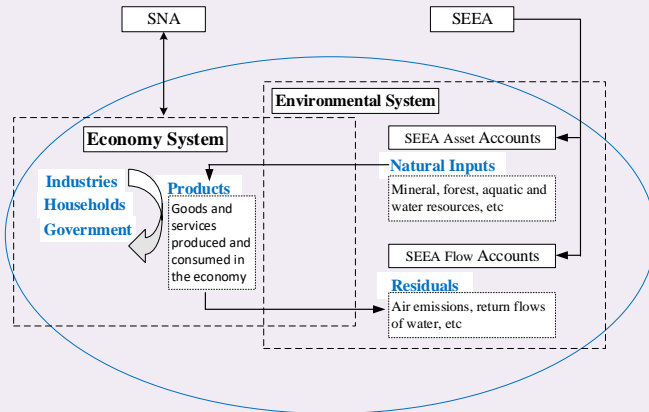


Figure 1: The relationship between SNA and SEEA.

SNA, SEEA and natural resources accounting

System of Environmental Economic Accounting

- In 2012, SEEA Central Framework and SEEA Experimental Ecosystem Accounting (SEEA EEA).
- Environmental assets provide economic benefits to an economic owner.
- The scope of environmental assets measured in the SEEA Central Framework is greater than the scope of environmental assets following the SNA definition of economic assets (UN et al. (2014), Paragraph 5.39).
- SEEA Central Framework for different nations, including NAMEA (Netherlands), SERIE (European Union), GEEA (Germany), IEESA (United States), and CSEEA (China) (Ouyang and Jin, 2018).

SEEA Limitations

- SEEA refers the contents of resources over-exploitation, pollutant emission, and ecological degradation, there is still a lack agreement on accounting slopes and methods.
- SEEA has not mentioned the concept of environmental liability.
- This lack of agreement has limited the potential for the failure to affix the responsibility of environmental pollution and resource destruction and most importantly, limited the wider uptake of natural resources liability thinking in policy and decision-making.

Natural resources accounting

1. Global value of ecosystem services (Costanza et al. 1997)
 - Natural capital (MacDonald et al. (1999))
 - Ecosystem services (Kosoy and Corbera (2010); Paulin et al. (2019); Polasky et al. (2011))
 - Gross ecosystem product (Ouyang et al. (2020,2013))
 - Ecological asset (Obst et al. (2016); Vačkářa and Grammatikopoulou (2019))
2. Environmental asset (Bartelmus (2014)) and services (Liu and Kontoleon (2018); Muradian et al. (2010))
3. Hambira(2007) has developed the natural resources accounting framework to integrate water resources management in Botswana
4. Gundimeda et al. (2007) have established natural resources accounting framework to reflect the value of forest resources in India based on SEEA framework

Ecological liability, environmental liability and natural resource liability

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Ecological liability, environmental liability and natural resource liability

Ecological liability concept

1. The restoration costs for tech-economic environmental harms and the capital required to pay for recurring repair efforts (Warlenius et al., 2015)
2. Loss of bio-diversity-populations of vertebrate species as well as the emissions of greenhouse gas and pollutants (Wang and Zhang, 2008).
3. The ecological debts are estimated the environmental costs of human activities in six major categories (climate change, stratospheric ozone depletion, agricultural intensification and expansion, deforestation, overfishing, and mangrove conversion) (Srinivasan et al. 2008).

Ecological liability, environmental liability and natural resource liability

Ecological liability accounting

4. The distribution disparity of ecological service consumption between ecological footprint and bio-capacity (Xie et al., 2010).
5. Accounting for liabilities for ecosystem degradation and investigated scenario analysis and modeling of a pastoral livestock operation that leases land in the northern rangelands of Western Australia (Ogilvy et al., 2018).
6. Ecological asset balance sheet (Ouyang and Jin, 2018).
7. Review on ecological liability (Warlenius et al., 2015).

Ecological liability, environmental liability and natural resource liability

Environmental liability

1. United Nations Conference on Trade and Development, the obligations relating to environmental costs, which are incurred by an enterprise and that meet the criteria for recognition as a liability (Adams et al., 1998).
2. Cardoso (2015) aimed to identify and value environmental liabilities from coal mining at different stages of the coal life cycle in Cesar.
3. Chen et al (2014) investigated that overall level of environmental liability amounts was consistently decreasing over the time frame examined, suggesting that earlier adoption would have made more sense.
4. Friehe and Langlais (2017) explored incentives for accident prevention and cleanup when firms are subject to environmental liability.

Ecological liability, environmental liability and natural resource liability

Environmental liability

5. The antecedents and economic consequences of corporate environmental performance and the related disclosures (Schneider et al., 2017)
6. Negash and Lemma (2020) investigated the role of institutional forces in shaping corporate accounting and reporting for environmental liabilities practice within the context of South Africa.

Ecological liability, environmental liability and natural resource liability

Natural resource liability: National Oceanic and Atmospheric Administration of United States in 1996, was incorporated in order to implement the natural resource liability provisions of the Oil Pollution Act.

The natural resource liability statutes have embodied a clear preference that trustees ensure the restoration of injured resources to their baseline levels and that recoveries for interim losses from the time of the incident until resource recovery also be spent on restoring, rehabilitating, replacing, or acquiring the equivalent of the injured natural resources. (Jones and Pease, 1997)

- Assess the trade-offs between gains from proposed actions and interim losses from the injuries (Jones, 2000).
- Habitat equivalency analysis (HEA) to assess the injuries of ecological services (Jones and DiPinto, 2018)

Ecological liability, environmental liability and natural resource liability

Natural resource liability

- The current obligation that the economic entities must undertake for the excessive consumption of public resources, which hinders production conditions and economic growth(Xiang and Zheng, 2016).
- The amount of relevant economic value produced by compensation for resources that need to be used or have been used with ecological environmental value (Ouyang and Jin,2018).
- The previous business activities, accidents, or anticipated events of the natural resource accounting entity have resulted in the net loss of natural resources and the negative impact on the environment and ecology (Du et al., 2018)
- Consists of three aspects: over-exploitation of natural resource, environmental pollution and ecological degradation.

Ecological liability, environmental liability and natural resource liability

Difference

- The former emphasises on the use of the legal liability to enable the trustees to recover damages for injuries to public resources.
- The latter attaches importance to the establishment of natural resources liability account, which can play a role in halting and reversing the damage of human to nature.

These liability accounts enable government to recognize the cost of environmental pollution, ecological degradation and resource exhaustion, attribute the cost to the entities responsible, and assure the entities shift the growth pattern coexisting with nature.

Natural resources balance sheet

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- **Natural resources balance sheet**

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Natural resources balance sheet

Existing literatures

- Water resources balance sheet (Chai et al., 2016; Jia et al., 2017; Song et al., 2018; Tian et al., 2018)
- Forest resources balance sheet (Deng, 2018; Lu, 2018)
- Mineral resources balance sheet (Geng et al., 2019; Ji and Liu, 2016; Li and Zhang, 2015)
- Marine resources balance sheet (He et al., 2017; Li et al., 2018))
- Regional natural resources balance sheet (for example Huzhou City (Yan et al., 2017) and Chengde City (Yang et al., 2017))

limitations

- Determine the accurate value of natural resources in practice
- The justification of the existence and accounting methods for natural resources liability are driving innovative work to bring the liability information and affix responsibility into decision making.
- The compilation of NRBS should not only adopt the accounting principle of balance sheet itself but affix the responsibility of the leading cadres for lack of adequate supervision also.

Challenges

- Estimating the physical quantity and monetary value of natural resources asset
- Investigating whether natural resources liability should be recognized
- Estimating the physical quantity and monetary value of natural resources liability;
- Compiling a coherent and compliant balance sheet of nature resources;
- Presenting a theoretic responsibility list of liability based on natural resources property rights regimes.

Accounting framework

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Accounting framework

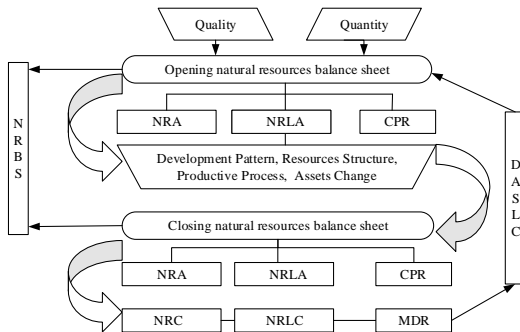


Figure 2: Mind map of natural resources balance sheet compilation. NRA: Natural Resources Assets Accounting, NRLA: Natural Resources Liabilities Accounting, CPR: Confirmation of Property Rights, NRC: Natural Resources Assets Changes, NRLC: Natural Resources Liabilities Changes, MDR: Measurement and Division of Responsibility, NRBS: Natural Resources Balance Sheet, DASLC: Departure Audit System for Leading Cadres.

Accounting framework

Table 1: NRBS index system

Account	Items	Contents
Asset		
	Land	Cultivated land, garden, woodland, grassland, built-up and related areas (construction), traffic land, maintenance and restoration of environmental functions (maintenance) and others
	Energy	Oil, Natural gas, Coal
	Mineral	Antimony, Gold, Mercury, Lead, Molybdenum, Zinc, Iron, Sodium Salt NaCl, Cement limestone, Glass quartzite
	Water	Surface water, groundwater, soil water
	Forest	Cultivated timber, natural timber
Liability		
	Resources	Depletion of non-renewables, bio-diversity loss
	Over-exploitation	
	Environmental	Air pollution, water pollution, solid waste pollution
	Pollution	
	Ecosystem	Climate change, stratospheric ozone-layer depletion, agricultural intensification and expansion, overfishing, flood prevention and soil erosion
	Degradation	

Key accounting concepts

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- **Key accounting concepts**
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Natural resources asset accounting

- NRBS should preferably be readily calculable from available data.
- Resources classification: Land, energy, mineral, water and forest (SEEA Environmental Asset Accounts)
- How can we evaluate the price for different kinds of land ?
- How can we acquire a credible price for a variety of energy and mineral with drastically changing market prices ?

The paper uses data on market prices where available and accessible, and develop methods to estimate surrogate prices where market prices do not exist for natural resources. Finally, we combine the values of varieties of nature resources into an asset account of NRBS.

Existence of natural resources liability (Disagree)

- According to the stipulations of SNA 2008 and SEEA 2012, it is inappropriate to confirm the liability of status of nature resources with the unclear property-ownership and undefined debtor-creditor relationship.
- The SEEA 2012 has established the equilibrium relation of "the source of the asset=the possession of asset" and taken no place and position on the potential to account for nature resources liability (Song et al., 2019).
- The SEEA-experimental Ecosystem Accounting has taken a relatively negative position on the potential to account for liabilities related to degradation of ecosystems (Ogilvy et al., 2018).

Key accounting concepts

Existence of natural resources liability (Agree)

- As a standard macroeconomic balance sheet described in SNA, the accounting equation of $\text{Asset} = \text{Liability} + \text{Owner's equity}$ implies the potential existence of natural resources liability (Collis et al., 2017).
- Assess the loss and liability of exploitation of natural resources and resultant environmental pollution and ecological destruction (Feng et al., 2014).
- It is of officials' responsibility to maintain the natural condition and take action to reverse nature deteriorates enforced by the rule of DASLC.

Key accounting concepts

Existence of natural resources liability (Agree)

- The environmental and ecological impact of over-exploitation of natural resources has also raised concern about the consequent threat to the human well-being (Cardoso, 2015).
- The destructions of human to nature are not fully 'captured' in commercial markets or adequately quantified in economic system, they are often given too little weight in policy decision making.
- The existence of natural resources liability reveals the attitude of liability subject toward nature protection, and provides reliable and useful information for appraising a liability entity's economic development pattern and the awareness level of environmental and ecological restoration (Song et al., 2019)

Key accounting concepts

Existence of natural resources liability (Agree)

Hence, we completely agree that natural resources liability is not perfect indicator for measuring the destruction of human to nature, but it is a good start to mimic or approximate the liability.

Key accounting concepts

Natural resources liability accounting

Consist of over-exploitation of nature resources, environmental pollution and ecological degradation

- Resources over-exploitation: depletion of nonrenewable resources and bio-diversity loss.
- Environmental pollution covers three aspects: air pollution, water pollution and solid waste pollution.
- Ecological degradation: greenhouse gas emission, stratospheric ozone depletion, agricultural intensification and expansion, deforestation, overfishing, and mangrove conversion.
- Expenditure of prevention of flood and soil erosion.

The principle for compiling NRBS

Asset = Liability + Owner's equity

- China is a country dominated by public ownership, which indicates that natural resources are owned by the state (owned collectively by all individuals)
- The amount of capital investigated by the entity subject and the remnant earnings cannot be directly calculated, the net worth can only be measured by the balance between natural resources asset and liability (Song et al., 2019) .
- Natural resources belong to the authorities and are managed by Ministry of Natural Resources (MNR) of China established in 2018.

Considering the similar situations in (Ogilvy et al., 2018), we adopt the compilation principle of “Net worth = Natural resources asset – Natural resources liability”.

Affix responsibility of the liability

- Property rights regimes (public ownership and collective ownership).
- Before 2018, the difference between the control rights and authoritative rights is ambiguous. All the governments serve as acting managers and supervisors (Song et al., 2019)
- The collective ownership of natural resources led to the phenomenon of owner absence. The state is the virtual subject of rights.
- The main problems that the natural resources property right system is facing include unclear property ownership, severe loss of property rights, asset exchange deviation from market rule and imperfect management system (Ma and Liu, 2015)

Key accounting concepts

Property rights regimes of natural resources

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- The collective ownership of natural resources led to the phenomenon of owner absence. The state is the virtual subject of rights.
- The main problems that the natural resources property right system is facing include unclear property ownership, severe loss of property rights, asset exchange deviation from market rule and imperfect management system (Ma and Liu, 2015)

These imperfect mechanism hinders the utilization efficiency in resources managements for a lack of motivation and supervision.

Key accounting concepts

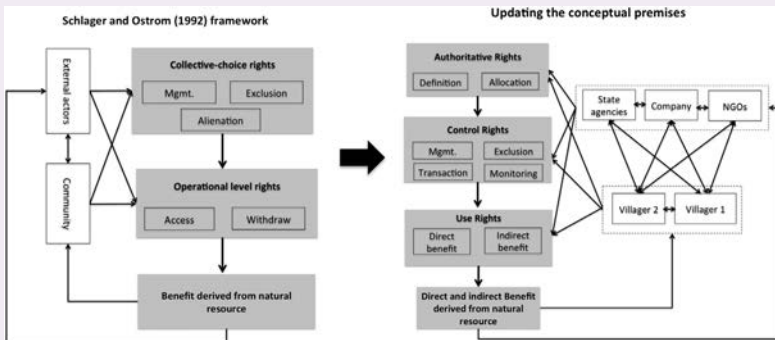
Established Ministry of Natural Resources and Ministry of Ecology and Environment in 2018



Key accounting concepts

Modern natural resource governance (Sikor et al., 2017)

- Use rights (use of direct benefits, use of indirect benefits)
- Control rights (management, exclusion, transaction, monitoring)
- Authoritative rights(definition, allocation)



Key accounting concepts

Affix responsibility of the liability

The natural resources liability consists of four elements: debtor, creditor, repayment period, and expenditures.

- The main creditor of natural resources over-exploitation liability should be MNR while the main creditor of ecosystem degradation and environmental pollution should be MEE.
- The debtor may be individuals, companies or organizations, who create the natural resources liability.
- The detailed methods for expenditures of all the liability are presented in Appendix.
- As for the repayment period, considering the complexity and urgency of practical situation, this problem still seems to be unsolved issue.

Compilation steps

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- **Compilation steps**

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Compilation steps

Three compilation principle (Feng et al., 2014)

- Trying the compiling each specific type of natural resource on balance sheet before resorting to restoring NRBS for multiple of natural resources
- Trying the physical quantity accounting before resorting to monetary accounting;
- Trying the stock accounting of natural resources before resorting to the flow accounting

Compilation steps

- Collecting the physical quantity and quality data of different natural resources asset types and natural resources liability types within a regional area of interest (state, province, city, county).
- Assessing the value of different natural resources assets based on reliable monetary methods and measuring the potential loss of different natural resources liabilities based on the widely recognized evaluation methods.
- Understanding of natural resources property rights regimes of interested area and establishing a feasible strategy or mechanism for affixing the liability based on national and regional conditions of legal and institutional system.
- Designating the period that the compilation of NRBS at the opening and closing date and calculating the change of physical quantity and financial quantity over the period.
- Analyzing the gain and loss of natural resources management and official governance and further presenting the suggestions of policy implications.

Study area

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

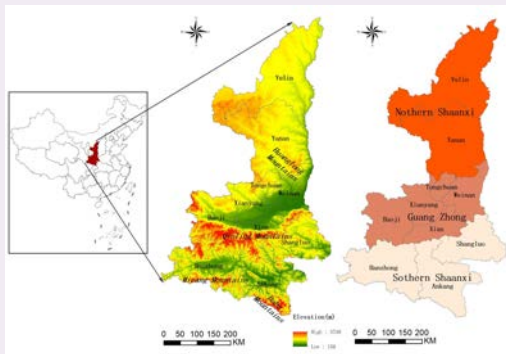
4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

Study area

Digital elevation map and regional division of Shaanxi Province, China.



Various of natural resources assets

- Shaanxi provides an important store of energy (coal, oil, natural gas, etc) and mineral (iron, molybdenum, copper, etc) for much of China.
- The land use types cover farmlands, grasslands, shrubs, sparse woodlands, and woodlands (Liu et al., 2019).
- Known as the "central water tower" of China, Qinling Mountains is the main sources of Jialingjiang River, Lou River, Wei River and Hanjiang River.
- The Qinling Mountains are also rich in mineral resources and high in forest coverage.
- Shaanxi provides 22.0 billion m^3 of water annually for other parts of China.
- The area of forest in Shaanxi is nearly 8.9 million hectares with the reserves of 479.0 million m^3 .

Severe destruction of nature

- The hilly area in Northern Shaanxi probably has the highest soil erosion rate in the world (Fu et al., 2000).
- The Qinling Mountains are threatened by illegal mining and overcutting.
- Liu et al. (2019) summarized that soil and water loss, deforestation, and desertification became a key concern for Shaanxi government.
- Hou et al. (2015) criticized that Shaanxi has lost its natural protective and productive functions in China.
- Shaanxi Province has implemented a number of ecological restoration programs (the Grain-for-Green Program, Natural Forest Protection Program, etc).
- The study area has a rich energy and mineral resources as well as fragile ecological environment with obvious spatial heterogeneity in climate, topography and vegetation types.

Data resources and monetary methods

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- **Data resources and monetary methods**
- NRBS Accounting in Shaanxi province

5 Conclusion

Data resources and monetary methods

Data resources and monetary methods for natural resources assets

Accounting	Item	Monetary Method	Data Source
Land	Cultivated land	Income capitalization approach (ICA) is used for valuing the cultivated land at provincial scale. The calculation formula is $V = \frac{P}{R} \left(1 - \frac{1}{(1+R)^N}\right)$, where V is the present value of the land, P total rents of land, R is the rate of interest to land, N is the year of earning period. According to Zhu and Du (2017) , the price of unit hm^2 for Shaanxi Province is 158889.75 Yuan in 2016. The above ICA method is also used for valuing garden, woodland and grassland at provincial scale. The total rents of garden, woodland and grassland are obtained from the right websites. The average of interest rate is 5%. According to the Land Administration Law of the People's Republic of China, N is 30.	Physical Quantity Shaanxi Provincial Land and Resources Bulletin in 2013 Shaanxi Provincial Land and Resources Bulletin in 2018 Rents http://www.tuliu.com/ http://www.jutubao.com/ https://www.cnhnb.com/p/tudi/ Interest Rate Zhu and Du (2017) Earning Period: http://www.npc.gov.cn/
	Garden		
	Woodland		
	Grassland		
	Construction	Data on the land amount of construction, traffic and maintenance are obtained from Shaanxi Provincial Land and Resources Bulletin. The average price of unit hm^2 for land acquisition is given by Department of Natural Resources of Shaanxi Province.	Land Acquisition Price http://zrzyt.shaanxi.gov.cn/info/1150/2780.htm http://zrzyt.shaanxi.gov.cn/info/1150/40632.htm
	Traffic land		
	Maintenance		
	Irrigation land	The price of irrigation land valued by Costanza et al. (1997) (\$ 14785/ha) is used. Data on the change of irrigation land are collected in China Forestry Statistical Yearbook.	

Data resources and monetary methods

Data resources and monetary methods for natural resources assets

Energy	Oil Natural gas Coal	Replacement costs method is used for valuing energy resources such as oil, natural gas and coal. Since the historical price of energy resource in Shaanxi is unavailable. We refer to the historical price in the US. The US annual average price of the oil in 2013 and 2018 are \$100.95 and \$57.77/barrel. The replacement cost of gas between 2013 and 2018 in Shaanxi is 1.95 Yuan/ m^3 . The replacement costs of coal in 2013 and 2018 are \$84 and \$107/t.	Physical Quantity Shaanxi Statistical Yearbook 2013 Shaanxi Statistical Yearbook 2018 Price reference https://www.statista.com/ https://inflationdata.com/
Mineral	Sodimu Salt NaCl Rock Gold Placer Gold Associated God Molybdenum Lead Zinc Mercury Antimony Cement Limestone Glass Quartzite Iron	The market value method is used for valuing mineral resources such as salt, gold, molybdenum and so on. The price of mineral resources in China is unavailable. We refer to the historical price in the United States Geological Survey (USGS). The annual price of salt, gold, molybdenum, lead, zinc, mercury, antimony, limestone, quartzite and iron are provided in the National Minerals Information Center of USGS. Data on the amount of mineral resources in Shaanxi province are obtained from Shaanxi Statistical Yearbook 2013 and 2018. Data on the other mineral resources are not recorded. The total monetary value of mineral is therefore underestimated.	Physical Quantity Shaanxi Statistical Yearbook 2013 Shaanxi Statistical Yearbook 2018 Price reference https://www.usgs.gov/centers/nmic/commodity-statistics-and-information

Data resources and monetary methods

Data resources and monetary methods for natural resources assets

Accounting	Item	Monetary Method	Data Source
Water	Surface water	According to Yan et al. (2018), water asset increases= rainfall+water inflows+socio-economic water return+others; water asset decreases=water utility+water outflows+others; closing stocks=opening stocks +water asset increases –water asset decreases. The unit price of water per m^3 estimated by Shaanxi Administration for Commodity Prices is applied for valuing water price in Shaanxi province. The average price between 2013 and 2018 is 4.69 Yuan/ m^3 .	Physical Quantity Shaanxi Water Resources Bulletin 2013 Shaanxi Water Resources Bulletin 2018 http://slt.shaanxi.gov.cn/ Price reference Bai et al. (2014)
	Groundwater		
	Soil water		
Forest	Cultivated timber	Market value method is used for valuing both natural and cultivated timber. According to China Forestry Statistical Yearbook, the unit price of timer in 2013 and 2018 are 754 Yuan/ m^3 and 569 Yuan/ m^3 . Data on non-timer forest are unavailable. The total forest asset is therefore underestimated.	Physical Quantity China Forestry Statistical Yearbook 2013 China Forestry Statistical Yearbook 2018
	Natural timber		

Data resources and monetary methods

Data resources and monetary methods for natural resources liabilities

Accounting	Item	Monetary Method	Data Source
Resources Over-exploitation	Depletion of non-renewable Biodiversity loss	According to Long and Ji (2019), the replacement cost method is employed. Since the price of energy and mineral resource is included, the detailed estimation is omitted here. Data on the consumption of energy resources are collected in China Energy Statistical Yearbook. Data on consumption of mineral resource are not reported in any official statistics. We convert the consumption of mineral resource into equivalent its production. Data on the production of mineral resource are obtained from Shaanxi Provincial Land and Resources Bulletin. Data on the biodiversity loss of Shaanxi are unavailable. We have to ignore the loss of biodiversity.	Physical Quantity China Energy Statistical Yearbook Shaanxi Provincial Land and Resources Bulletin
Environmental Pollution	Air pollution Water pollution Solid waste	The air pollution is rooted in the emission of SO ₂ , NO _x and Suspended Particles (SP). The unit environmental cost of SO ₂ , NO _x and SP estimated by Shen et al. (2017) is 1264 Yuan/t, 1264 Yuan/t and 550 Yuan/t, respectively. The water pollution includes the emission of COD and Ammonia Nitrogen. The unit cost of COD and Ammonia Nitrogen given by Shen et al. (2017) is 1400 Yuan/t and 1750 Yuan/t, respectively. Types of solid waste are household and industrial. The cost of the industrial solid waste includes general industrial solid waste disposal and storage as well as hazardous industrial solid waste disposal and storage. According to Long and Ji (2019), the unit cost of general industrial solid waste disposal and storage is 75 Yuan/t and 15 Yuan/t. The unit cost of hazardous industrial solid waste disposal and storage is 1500 Yuan/t and 300 Yuan/t. The unit cost of household solid waste is 27 Yuan/t. All the data of environmental pollution are obtained from Shaanxi Statistical Yearbook except for the amount of household solid waste. The latter data are recorded in	Physical Quantity Shaanxi Statistical Yearbook 2013 Shaanxi Statistical Yearbook 2018 China Urban Construction Statistical Yearbook 2013. China Urban Construction Statistical Yearbook 2018. Shaanxi Provincial Environmental Bulletin 2013 Shaanxi Provincial Environmental Bulletin 2018

Data resources and monetary methods

Data resources and monetary methods for natural resources liabilities

Table 11: Items description and monetary methodologies of natural resources liabilities (continued)

Accounting	Item	Monetary Method	Data Source
Ecological Degradation	Climate change	The driver of climate change is the emission of greenhouse gas (GHG)(Srinivasan et al. (2008)). The average cost of GHG emissions between 1992 and 2012 estimated by Liang et al. (2015) is 47.03 Yuan/t. Data on GHG are obtained from the CEADs database provided by Shan et al. (2017, 2020, 2016).	Physical Quantity CEADs: Carbon Emission Accounts and Datasets https://www.ceads.net/
	Stratospheric ozone-layer depletion	The ozone depleting substances (ODS) is rooted in the emission of Chlorofluorocarbon. The related data are unavailable for Shaanxi Province during 2013-2018.	Shaanxi Statistical Yearbook 2018
	Agricultural intensification and expansion	Following Srinivasan et al. (2008), the agricultural intensification and expansion is measured by the external costs of crop production. The united external cost of crop estimated by Tegmeier and Duffy (2004) is applied. The annual external costs of crop production for water,soil,air,biodiversity,human-health are 11.50,85.86, 10.85, 43.35, 38.64 Yuan/hm ² . Data on the area of crops are available in the Chapter of Total Sown Areas of Major Farm of Shaanxi Statistical Yearbook.	
	Overfishing	The value of overfishing is mainly about the gross output value of fishery. Data on the value of fishery are available in the Chapter of Gross Output Value of Fishery of Shaanxi Statistical Yearbook.	Shaanxi Statistical Yearbook 2018
	Flood prevention and soil erosion	Cost of flood prevention and soil erosion is estimated by ecological projects the investment of soil and water conservation. Since only economic costs are considered, this term is underestimated. The replacement cost method is employed in the above items.	China Statistical Yearbook on Environment 2018

NRBS Accounting in Shaanxi province

1 Introduction

- Background
- Policy

2 Literature Review

- SNA, SEEA and natural resources accounting
- Ecological liability, environmental liability and natural resource liability
- Natural resources balance sheet

3 Methodology

- Accounting framework
- Key accounting concepts
- Compilation steps

4 Case Study

- Study area
- Data resources and monetary methods
- NRBS Accounting in Shaanxi province

5 Conclusion

NRBS Accounting in Shaanxi province

Table 2: Opening natural resources balance sheet in Shaanxi province at December 31, 2013

Assets				Liabilities			
Category	Accounting Item	Physical quantity	Monetary value	Category	Accounting Item	Physical quantity	Monetary value
Land	($\times 10^4$)	km ²	(billion Yuan)	Resources overexploitation	($\times 10^4$)	t	(billion Yuan)
	Cultivated land	39.92	1054.70	Depletion of non-renewable			
	Garden	8.26	2892.94	Coal	172.47	102.13	
	Woodland	112.03	5652.94	Oil	11.76	59.55	
	Grassland	28.74	1739.60	($\times 10^{10}$)	m ³		
	Construction	0.26	11.33	Natural gas	7.03	13.70	
	Traffic land	2.48	109.19	($\times 10^7$)	t		
	Irrigation land	3.10	29.59	Iron	5.03	2.84	
Energy	($\times 10^{10}$)	t		Molybdenum	17.09	25.26	
	Coal	163.97	1393.73	Lead	0.04	0.59	
	Oil	0.34	1706.43	Zinc	0.71	8.75	
	($\times 10^{10}$)	m ³		Biodiversity loss			
	Natural gas	623.11	1215.08		–	–	
Mineral	($\times 10^3$)	t		Environmental pollution	($\times 10^3$)	t	
	Antimony	27.55	1.82	Air pollution			
	Gold	0.35	82.45	SO ₂	0.81	1.02	
	Mercury	1.50	0.94	NO _x	0.76	0.96	
	($\times 10^7$)	t		SP	0.54	0.30	
	Lead	1.59	22.03	Water pollution			
	Molybdenum	1.02	185.62	COD	0.52	0.73	
	Zinc	3.51	43.45	Ammonia Nitrogen	0.06	0.10	
	($\times 10^{10}$)	t		Solid waste			
	Iron	0.78	441.68	Household waste	4.21	0.11	
	Sodium Salt NaCl	885.53	1284.02	Industrial solid waste disposal	16.22	1.22	
	Cement limestone	7.68	7.68	Waste storage	11.31	0.17	
	Glass quartzite	0.19	0.22	Hazardous industrial waste disposal	0.12	0.18	
Water	($\times 10^{10}$)	m ³		Waste storage	0.09	0.03	
	Surface water	33.15	155.46	Ecological degradation	($\times 10^7$)	t	
	Groundwater	11.85	55.59	CO ₂	265.60	12.47	
	Soil water	145.69	683.30	Stratospheric ozonolayer depletion	–	–	
Forest	($\times 10^7$)	m ²		($\times 10^3$)	hm ²		
	Cultivated timber	2.36	1.79	Agricultural intensification and expansion	4108.22	0.78	
	Natural timber	5.32	4.01	Flood prevention and soil erosion	667.00	0.93	
				Overfishing	–	1.78	
Total Assets:			18775.59	Total Liabilities:			2333.60
Net Worth:			18541.99				

NRBS Accounting in Shaanxi province

Table 3: Closing natural resources balance sheet in Shaanxi province at December 31, 2018

Assets				Liabilities			
Category	Accounting Item	Physical quantity	Monetary value	Category	Accounting Item	Physical quantity	Monetary value
Land	($\times 10^3$)	km ²	(billion Yuan)	Resources overexploitation	Depletion of non-renewable	t	(billion Yuan)
	Cultivated land	39.77	1050.68		Coal	193.96	127.04
	Garden	8.15	2854.25		Oil	7.78	25.97
	Woodland	111.64	5633.29		($\times 10^{10}$)	m ³	
	Grassland	28.68	1735.67		Natural gas	10.55	20.58
	Construction	0.16	10.27		($\times 10^7$)	t	
	Traffic land	2.64	164.82		Iron	22.02	11.66
	Irrigation land	3.08	29.37		Molybdenum	16.43	28.66
Energy	($\times 10^{10}$)	t			Lead	0.03	0.45
	Coal	171.6	1458.98		Zinc	1.10	21.46
	Oil	0.35	1163.97		Biodiversity loss	–	–
	($\times 10^{10}$)	m ³		Environmental pollution	($\times 10^4$)	t	
	Natural gas	959.48	1870.98		Air pollution		
Mineral	($\times 10^4$)	t			SO ₂	0.22	0.28
	Antimony	41.70	1.53		NO _x	0.31	0.39
	Gold	0.46	93.75		SP	0.20	0.11
	Mercury	1.29	0.67		Water pollution		
	($\times 10^7$)	t			COD	0.18	0.25
	Lead	2.65	23.62		Ammonia Nitrogen	0.02	0.04
	Molybdenum	1.40	269.20		Solid waste		
	Zinc	4.71	68.42		Household waste	6.38	0.17
	($\times 10^{10}$)	t			Industrial solid waste disposal	66.11	4.96
	Iron	1.10	580.12		Waste storage	15.38	0.23
	Sodium Salt NaCl	928.60	1346.50		Hazardous industrial waste disposal	0.61	0.91
	Cement limestone	7.73	7.73		Waste storage	0.21	0.06
	Glass quartzite	0.19	0.23		($\times 10^4$)	t	
Water	($\times 10^{10}$)	m ³			CO ₂	276.17	12.98
	Surface water	34.75	163.00		Stratospheric ozonolayer depletion	–	–
	Groundwater	12.50	58.64		($\times 10^3$)	hm ²	
	Soil water	144.53	677.86		Agricultural intensification and expansion	4092.10	0.78
Forest	($\times 10^4$)	m ³			Flood prevention and soil erosion	228.80	5.05
	Cultivated timber	3.11	1.77		Overfishing	–	2.98
	Natural timber	5.76	3.28				
Total Assets: 19268.60				Total Liabilities: 265.01			
Net Worth: 19003.59							

NRBS Accounting in Shaanxi province

Table 4: Physical and monetary changes of natural resources assets account from 2013 to 2018

Category of asset	Accounting items	Physical quantity 2013-2018		2013 constant price 2013-2018		Current Price 2013-2018		Valuation	billion Yuan
		Amount change	Quantity	Amount change	Percent change	Amount change	Percent change	Unit price	Valuation method
Land									
	Cultivated land	-0.22 ↓	10 ³ km ²	-4.02 ↓	0.38%	-4.02 ↓	0.38%	26.42 × 10 ⁷ Yuan/km ²	Income capitalization method
	Garden	-0.11 ↓	10 ³ km ²	-38.69 ↓	1.34%	-38.69 ↓	1.34%	350.38 × 10 ⁷ Yuan/km ²	
	Woodland	-0.39 ↓	10 ³ km ²	-19.65 ↓	0.35%	-19.65 ↓	0.35%	50.46 × 10 ⁷ Yuan/km ²	
	Grassland	-0.06 ↓	10 ³ km ²	-3.93 ↓	0.23%	-3.93 ↓	0.23%	60.53 × 10 ⁷ Yuan/km ²	Market prices
	Construction	-0.10 ↓	10 ³ km ²	-4.09 ↓	36.10%	-1.06 ↓	9.36%	44.01 × 10 ⁷ Yuan/km ²	
	Traffic land	0.16 ↑	10 ³ km ²	7.04 ↑	6.45%	55.63 ↑	50.95%	44.01 × 10 ⁷ Yuan/km ²	
	Irrigation land	-0.02 ↓	10 ³ km ²	-0.22 ↓	0.74%	-0.22 ↓	0.74%	9.55 × 10 ⁷ Yuan/km ²	
Energy									
	Coal	7.63 ↑	10 ¹⁰ t	65.25 ↑	4.68%	65.25 ↑	4.68%	8.50 Yuan/t	Replacement costs method
	Oil	11.76 ↑	10 ⁷ t	65.88 ↑	3.49%	-542.46 ↓	31.79%	5061.64 Yuan/t	
	Natural gas	336.37 ↑	10 ¹⁰ m ³	655.90 ↑	53.98%	655.90 ↑	53.98%	1.95 Yuan/m ³	
Mineral									
	Antimony	14.15 ↑	10 ³ t	0.93 ↑	51.36%	-0.29 ↓	15.95%	65.95 × 10 ³ Yuan/t	Market prices
	Gold	0.11 ↑	10 ³ t	23.60 ↑	28.62%	11.30 ↑	13.71%	21.45 × 10 ⁷ Yuan/t	
	Mercury	-0.21 ↓	10 ³ t	-0.13 ↓	14.07%	-0.27 ↓	28.72%	0.63 × 10 ⁷ Yuan/t	
	Lead	1.06 ↑	10 ⁷ t	14.63 ↑	66.66%	1.59 ↑	7.21%	1.38 × 10 ⁴ Yuan/t	
	Molybdenum	0.38 ↑	10 ⁷ t	56.09 ↑	37.25%	83.58 ↑	45.03%	14.76 × 10 ⁴ Yuan/t	
	Zinc	1.20 ↑	10 ⁷ t	14.88 ↑	32.24%	24.97 ↑	57.47%	1.24 × 10 ⁴ Yuan/t	
	Iron	0.32 ↑	10 ¹⁰ t	180.74 ↑	40.92%	138.44 ↑	31.34%	564.80 Yuan/ t	
	Sodimu Salt NaCl	43.07 ↑	10 ¹⁰ t	62.48 ↑	4.87%	62.48 ↑	4.87%	1.45 Yuan/t	
	Cement limestone	0.05 ↑	10 ¹⁰ t	0.05 ↑	0.65%	0.05 ↑	0.65%	1.00 Yuan/t	
	Glass quartzite	0.002 ↑	10 ⁹ t	0.0024 ↑	1.09%	0.0024 ↑	1.09%	1.20 Yuan/t	
Water									
	Surface water	1.60 ↑	10 ¹⁰ m ³	7.54 ↑	4.85%	7.54 ↑	4.85%	4.85 Yuan/m ³	Market price
	Groundwater	0.65 ↑	10 ¹⁰ m ³	3.05 ↑	5.49%	3.05 ↑	5.49%	4.85 Yuan/m ³	
	Soil water	-1.16 ↓	10 ¹⁰ m ³	-5.44 ↓	0.80%	-5.44 ↓	0.80%	4.85 Yuan/m ³	
Forest									
	Cultivated timber	0.75 ↑	10 ⁷ m ³	0.57 ↑	31.78%	-0.02 ↓	1.11%	754.00 Yuan/m ³	Market price
	Natural timber	0.44 ↑	10 ⁷ m ³	0.33 ↑	8.27%	-0.73 ↓	18.20%	754.00 Yuan/m ³	

NRBS Accounting in Shaanxi province

Table 5: Physical and monetary changes of natural resources liabilities account from 2013 to 2018

Category of liability	Accounting items	Physical quantity 2013-2018		2013 constant price 2013-2018		Current Price 2013-2018		Valuation Unit price	billion Yuan Valuation method
		Amount change	Quantity	Amount change	Percent change	Amount change	Percent change		
Resources overexploitation	Depletion of non-renewables								
	Coal	21.49 ↑	10 ⁷ t	12.60 ↑	12.34%	24.91 ↑	24.39%	586.32 Yuan/t	Replacement cost method
	Oil	-3.98 ↓	10 ⁷ t	-20.15 ↓	33.84%	-32.58 ↓	54.71%	5061.64 Yuan/t	
	Natural gas	3.52 ↑	10 ¹⁰ m ³	6.86 ↑	50.07%	6.88 ↑	50.22%	1.95 Yuan/m ³	
	Iron	16.99 ↑	10 ⁷ t	9.60 ↑	337.78%	8.82 ↑	310.56%	564.80 Yuan/t	
	Lead	-1.24 ↓	10 ⁴ t	0.17 ↓	28.81%	-0.14 ↓	23.72%	1.38 × 10 ⁴ Yuan/t	
	Molybdenum	-0.66 ↓	10 ⁷ t	-0.97 ↓	3.84%	3.40 ↑	13.46%	14.76 × 10 ⁴ Yuan/t	
	Zinc	0.39 ↑	10 ⁷ t	4.84 ↑	55.31%	12.71 ↑	145.26%	1.24 × 10 ⁴ Yuan/t	
	Biodiversity loss	—	—	—	—	—	—	—	
Environmental pollution	Air pollution								
	SO ₂	-0.59 ↓	10 ⁷ t	-0.74 ↓	72.55%	-0.74 ↓	72.55%	1264.00Yuan/t	Imputed abatement cost method
	NO _x	-0.45 ↓	10 ⁷ t	-0.57 ↓	59.38%	-0.57 ↓	59.38%	1264.00Yuan/t	
	SP	-0.34 ↓	10 ⁷ t	-0.19 ↓	63.33%	-0.19 ↓	63.33%	550.00Yuan/t	
	Water pollution								
	COD	-0.34 ↓	10 ⁷ t	-0.48 ↓	65.75%	-0.48 ↓	65.75%	1400.00Yuan/t	
	Ammonia Nitrogen	-0.04 ↓	10 ⁷ t	-0.06 ↓	60.00%	-0.06 ↓	60.00%	1750.00Yuan/t	
	Solid waste								
	Household waste	2.17 ↑	10 ⁷ t	0.06 ↑	54.55%	0.06 ↑	54.55%	27.00 Yuan/ t	
	Industrial solid waste disposal	49.89 ↑	10 ⁷ t	3.74 ↑	306.56%	3.74 ↑	306.56%	75.00 Yuan/t	
	waste storage	4.07 ↑	10 ⁷ t	0.06 ↑	35.29%	0.06 ↑	35.29%	15.00 Yuan/t	
	Hazardous industrial waste disposal	0.49 ↑	10 ⁷ t	0.73 ↑	465.56%	0.73 ↑	465.56%	1500.00 Yuan/t	
	waste storage	0.12 ↑	10 ⁷ t	0.03 ↑	132.37%	0.03 ↑	132.37%	1.20 Yuan/t	
Ecological degradation	CO₂	10.57 ↑	10 ⁷ t	0.51 ↑	4.09%	0.51 ↑	4.09%	47.03 Yuan/t	Imputed abatement cost method
	Stratospheric ozonelayer depletion	—	—	—	—	—	—	—	
	Agricultural intensification and expansion	-16.12 ↓	10 ³ hm ²	-0.003 ↓	0.38%	-0.003 ↓	0.38%	190.21 Yuan/hm ²	
	Overfishing	—	—	1.20 ↑	167.48%	1.20 ↑	167.48%	—	
	Flood prevention and soil erosion	-438.20 ↓	10 ³ hm ²	4.12 ↑	443.01%	4.12 ↑	443.01%	—	

NRBS Accounting in Shaanxi province

Table 6: Change of NRBS and GDP in Shaanxi from 2013 to 2018

Content	constant price		Amount change (billion Yuan)	Percent change (%)
	2013	2018		
NRBS				
Natural resources assets	18775.59	19268.60	493.01	2.63%
Natural resources liabilities	233.60	265.01	31.41	13.45%
Net Worth	18541.99	19003.59	461.60	2.49%
GDP	1620.55	2394.19	773.64	47.74%

NRBS Accounting in Shaanxi province

Measurement and division of responsibility for natural resources liability

Table 7: Natural resources liability with property rights regimes

Types	Resources over-exploitation	Environmental pollution	Ecological degradation
Authoritative rights			
Definition	SC and CPC promulgate laws and regulations and define the slope of control rights in MNR and related agencies.	SC and CPC promulgate laws and regulations and define the slope of control rights in MEE and related agencies.	SC and CPC promulgate laws and regulations and define the slope of control rights in MEE and related agencies.
Allocation	SC and CPC designate MNR as trustees of the resources on behalf of the public. SC and CPC allocate management and exclusion right to DMN. SC allocates transaction and monitoring rights to FD and SACMS.	SC and CPC designate MEE as trustees of the environment on behalf of the public. SC and CPC allocate management, exclusion, transaction, monitoring rights to DEE.	SC and CPC designate MEE as trustees of the ecology on behalf of the public. SC and CPC allocate management, exclusion, transaction, monitoring rights to DEE.
Control rights			
Management	DMN determines management practices.	DEE determines management practices.	DEE determines management practices.
Exclusion	DMN and FD	DEE	DEE
Transaction	Companies sell a variety of production of mineral and energy.	Companies buy a variety of Shaanxi Province pollution emission quotas such as air and water pollutant.	Companies buy Shaanxi Province CO ₂ emission quotas. Many ecological restoration programs are disbursed by government.
Monitoring	DMN and local government.	DEE and local government.	DEE and local government.
Use rights			
Direct benefits	Companies	Companies	Companies, farmers, fishermen
Indirect benefits	The government collects taxes.	The government uses charges to control the total pollutant emission.	The government uses charges to decrease CO ₂ emission.

Note: SC: The State Council, NPC: The National People's Congress, MNR: Ministry of Natural Resources, MEE: Ministry of Ecology and Environment, DMN: Department of Natural Resources of Shaanxi Province, FD: Financial Department of Shaanxi Province, DEE: Department of Ecology and Environment of Shaanxi Province, DWR: Department of Water Resources of Shaanxi Province, SACMS: Shaanxi Administration of Coal Mine Safety.

Meet the requirement of practical demand

- Urgent need for better accounting framework of natural resources management and restoration, and the integration of the gain and loss of natural resources into government supervision and official assessment.
- The account should provide policy makers with clear information that what is the quantity and valuation of natural resources in the region as well as what is the total cost of environmental pollution and ecological degradation.
- The account also enables the government to affix the responsibility of principal officials for inadequate supervision.
- NRBS provides a useful statement of natural resources assets and liabilities in the region.
- The latter enables us to understand the underlying contribution of nature to human well-being and the damage of human to nature.

Contribution

- We develop the accounting framework, key concept, and compilation steps to establish the NRBS in the region.
- Case study of Shaanxi province demonstrates that NRBS is a promising approach to account for the value of natural resources to human well-being and the cost of human to nature with available data and monetary methods.
- The physical and monetary changes of natural resources assets and liability can be incorporated into government arrangement and official performance.

Future work

- It can be complicated to separate the accounting value of natural resources from the contribution of human labor.
- The limitation of data and methods leads to the imprecise estimation of bio-diversity loss and ecological cost of mineral and energy exploitation.
- How to investigate the relationship between natural resources assets and liabilities on property right regimes and deserves to be further explored.



Thank you!