Integrating Natural Capital into Policy Design in China: Qinghai pilot

Global Environmental Institute

TRUCOST

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About Trucost

Trucost has been helping companies, investors, governments, academics and thought leaders to understand the economic consequences of natural capital dependency since 2000.

Our world leading data and insight enables our clients to identify natural capital dependency across companies, products, supply chains and investments; manage risk from volatile commodity prices and increasing environmental costs; and ultimately build more sustainable business models and brands. Key to our approach is that we not only quantify natural capital dependency, we also put a price on it, helping our clients understand environmental risk in business terms.

It isn't "all about carbon"; it's about water; land use; waste and pollutants. It's about which raw materials are used and where they are sourced, from energy and water to metals, minerals and agricultural products. And it's about how those materials are extracted, processed and distributed.

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Contents

Executive Summary

The Global Environment Institute (GEI) commissioned Trucost to quantify the environmental value of ecosystem services under conservation in the Qinghai region of China, and quantify the environmental damage costs from business activities in the Chinese province.

Qinghai is located in the northwest of China distinguished by its high conservational value. The region contains some of the most abundant ecosystems in China and important rivers in Asia, such as the Yellow river. As part of the remote Tibetan plateau, it has not been as affected by urbanization and industrialization as other areas of China. The Qinghai province plays an important role in providing ecosystem services such as climate regulation, water regulation and the production of raw materials.

As China continues its economic expansion in the coming years, Qinghai could face increasing pressure on its fragile ecological system from environmental impacts such as global warming, overgrazing and desertification.

The objectives of this research were to assess the main ecosystem services in Qinghai and the impacts of the most important industrial sectors in the region. The research went on to assess the influence that different regional policies can have on natural capital in order to prioritize environmental protection and ensure sustainable development in the province.

Based on the quantitative assessment of environmental externalities, this study provides recommendations to help policy makers:

- Allocate government funding in a way that reflects the environmental benefits generated through nature conservation to society at large
- Integrate environmental protection into economic policies
- Provide a comprehensive assessment of sustainable development that benefits our society and protects our environment as well as achieving economic growth, in line with decoupling principles.

Key findings

- **The top 20 most significant sectors in Qinghai in terms of GDP contribution to the region and natural capital intensity are the energy, farming, mining and manufacturing sectors.** Examples are coal power generation, cattle ranching and farming, bituminous coal underground mining, and primary smelting and refining of non-ferrous metal respectively.

- **For these 20 sectors, greenhouse gas (GHG) emissions are responsible for the majority of the costs (73%), followed by water pollutants (17%) and land use (8%).** In addition, most of the costs come from the supply chain (68%) and are associated with impacts from upstream production activities and raw materials extraction.

- **Lead ore and zinc ore mining is the sector with the highest natural capital intensity** from the top 20 sectors identified in Qinghai. This is because of the impacts of water pollution caused by mining operations. Lead and zinc are both heavy metals that have a high toxic potential and can therefore significantly alter water quality.

- **Wetlands provide the highest level of natural capital benefits in Qinghai** because they are a very complex habitat that provides a wide range of ecosystem services. The surface area of wetlands is 80% smaller than for grasslands, but the natural capital benefits they deliver are greater. Wetlands also provide a higher level of ecosystem services than forests, such as hydrology regulation, waste regulation and aesthetic landscape provision.

- **If the increase in GDP from the Qinghai 13th Five-Year Plan (named policy 1) is achieved by 2020, there would be an additional CNY 61,325 million extra natural capital costs**, as a result of higher production levels in the region. **On the other hand, the increase in natural areas (named policy 2) in 2020 would lead to CNY 10,798 million extra natural capital benefits**, as a result of additional area dedicated to forest and grasslands habitats. The Qinghai 13th Five-Year Plan' contains a set of goals for 2020 some of which involve decreasing environmental impacts such as GHG emissions and water use intensities, or increasing natural areas, while others involve expanding economic production levels in the region.

- **When combining the two policies described above, there is a net increase in natural capital costs of CNY 50,527 million from 2015 to 2020, suggesting that natural capital would be negatively affected if these two polices were achieved.** Trucost recommends establishing additional policies that promote environmental protection or sustainable economic expansion to compensate for this loss.

- **The sectors that will face the great risks and challenges when looking at other targets from the Qinghai 13th Five-Year Plan and the China 13th Five-year plan are:**
    - Sectors expected to increase capacity while lowering resource use and emissions intensity (for example, hydroelectric power generation and coal power generation)
    - Sectors expected to increase production levels while lowering resource use intensity and emissions intensities (for example, bituminous coal underground mining and crude petroleum and natural gas extraction)
    - Carbon-intensive sectors (for example, energy sectors)
    - Water-intensive sectors (for example, agricultural sectors)

Potential Steps

- **The Qinghai 13th Five-year plan contains potentially contradictory goals to promote economic expansion and environmental protection. It is recommended that governments provide guidance to help industry achieve these goals in a holistic way by decoupling economic growth from environmental impacts.** Additional policies that incentivize resource efficient production and renewable energy would promote sustainable development in the region. Examples of these policies could be the creation of subsidies to support clean technology.

- **The Qinghai government could engage with the highly polluting sectors identified in this study to raise awareness of the risks and opportunities of their impact and dependency on natural capital.** Creating the structure to facilitate knowledge transfer between public and private sectors is critical to ensure Qinghai's transition to a low-carbon economy and the sustainable development of the region overall.

- **Qinghai government could use natural capital accounting as a supplemental metric to traditional GDP.** This approach is already being piloted by several local governments in China. Quantifying the overall effects and the dynamics of various policies could help the government identify potential constraints and determine priorities within the policy design and implementation phases.

- **Promoting science-based targets could help the government achieve sustainable development and transition Qinghai towards a green economy.** Science-based targets have been mainly adopted to encourage GHG reductions to keep the global temperature increase below 2 degrees Celsius, yet these types of targets can also be applied to conserve critical resources that support economic growth such as land use and water use.

- **Finally, additional research is recommended to provide further insight for policy makers.** For example, increasing the scope of the research to include further sectors from Qinghai economy could provide a more complete picture of the natural capital impacts in the region, and allow the identification of other polluting sectors for engagement. Furthermore, expanding this first pilot study to other important regions in China could allow GEI to support other local governments in policy decision making, with the ultimate aim of protecting the environment and conserving natural capital assets.

Glossary

TERM, ACRONYM OR ABBREVIATION	DEFINITION
ABATEMENT COST	Cost of reducing an environmental impact.
BENEFIT TRANSFER	Technique by which an environmental value is transferred from one location to another.
DALY	Disability adjusted life years. The DALY quantifies the burden of disease on human populations and represents the loss of one year of healthy life. This metric is normally used in Life Cycle Analysis (LCA) studies to quantify damages on human health.
DIRECT IMPACT	Impact from a company's own operations.
ECOSYSTEM	Dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Together with deposits of non-renewable resources they constitute 'natural capital'.
ECOSYSTEM SERVICES	Goods (renewable resources such as water and food) and services (such as pollination and purification of water) provided by specific ecosystems to humans. An overview is available at URL: http://www.teebweb.org/resources/ ecosystem-services.
EEIO	Environmentally extended input-output model: a model that maps the flow of inputs and environmental impacts through an economy.
EKPI	Environmental Key Performance indicator: environmental impact categories developed by Trucost for appraisal of businesses, sectors and regions.
EMISSION FACTOR	Unit of an environmental impact per unit of physical production.
ENVIRONMENTAL VALUE	The value to people from environmental goods and services. Where no market price exists, it can be estimated in monetary terms by using environmental valuation methods.
EXTERNAL COST	Cost borne by third parties not taking part in an economic activity.
FAO	Food and Agriculture Organization of the United Nations.
GHG	Greenhouse gas.
IMPACT	Environmental impact either in physical units or as a monetary value (cost).
INDIRECT IMPACT	Impact from a company's supply chain.
INTERNAL COST	Cost borne by parties taking part in an economic activity.
INTERNALISE	When the creator of external costs (e.g. a polluter) has to pay for those costs.
NATURAL CAPITAL	The finite stock of natural assets (air, water and land) from which goods and services flow to benefit society and the economy. It is made up of ecosystems (providing renewable resources and services), and non-renewable deposits of fossil fuels and minerals.
NATURAL CAPITAL INTENSITY	The ratio of total natural capital costs generated (CNY millions) relative to revenue generated (CNY millions)
NATURAL CAPITAL RISK	The risks associated with the internalization of natural capital costs through a risk driver such as environmental regulation.
PDF	Potentially disappeared fraction of species. This metric is normally used in Life Cycle Analysis (LCA) studies to quantify damages on ecosystems.
PRODUCTION VALUE	Economic output of the sector for a particular year (CNY millions).
SOCIAL COST	Cost to society as a whole of an action, such as an economic activity, equal to the sum of internal costs plus external costs.
US EPA	United States Environmental Protection Agency.
VOLY	Value of a life year. In this study, the value of a life year was determined using a WTP approach (see definition of WTP below).
WATER SCARCITY	Percentage of the annually renewable water resource used in a particular area.
WTP	Willingness to pay: a survey-based approach that is often used for the valuation of aspects not traded in the market, such as environmental protection or an increase in life expectancy.

SOURCE: ADAPTED FROM NATURAL CAPITAL AT RISK: THE TOP 100 EXTERNALITIES OF BUSINESS (TRUCOST, 2013)

Introduction

Qinghai is a vast province in the northwest of China characterised by its high conservational value. This region contains the most abundant ecosystem types in China and encompasses important rivers in Asia, for example the Yellow river or the Yangtze river (Han, et al. 2016). Being part of the remote Tibetan plateau, it has not been as affected by China's economic expansion in comparison to urban areas in the country. The Qinghai province is critical for the provision of ecosystem services such as climate regulation, water regulation and the production of raw materials (ibid). However, China is expected to continue with its economic expansion in the coming years: for example there are government goals promoting GDP increases at the national and regional level in the short term. This poses an important risk for areas such as Qinghai. The region's fragile ecological system has already started to be affected by global warming (Xiao et al., 2003; Zhang et al., 2015), desertification (Li et al., 2015) and over-grazing amongst others impacts (Han, et al. 2016).

'Natural capital valuation' is a technique that can provide insights for policy makers. By quantifying the influence that potential policies can have on the environment, it allows them to design policies that ensure environmental protection and sustainable development. In November 2015, China's State Council announced the "Natural Capital Balance Pilot Plan", which aims to integrate natural capital accounting into government, providing information to support policy making via pilot projects in five cities (State Council, 2015). This illustrates the increasing awareness and interest in natural capital accounting for government decision making.

Against this background, Global Environment Institute (GEI) commissioned Trucost to quantify the environmental damage costs from conventional business activities and assess the ecosystem services value generated by nature under conservation. The objectives of the research were to:

- Assess the main ecosystem services in Qinghai and the impacts from the most important industry sectors in the region
- Assess the influence that different regional policies can have in natural capital in order to prioritize environmental protection and ensure sustainable development for the province

Based on the quantitative measurement of environmental externalities, the study will provide evidence to: 1) Rationalize allocation of government funding that reflects the environment benefits generated through conservation effort to society at large: 2) Integrate environmental protection into economic policies; 3) Provide a comprehensive assessment of sustainable development that benefits society and protects the environment as well as achieving economic growth. In addition, GEI aims to use Qinghai as a pilot study and gradually expand its analysis to the rest of China to provide a comprehensive assessment to help policy makers prioritize environmental protection.

FIGURE 1. QINGHAI REGION AND MAJOR CITIES IN CHINA

SOURCE: TRUCOST (2016)

Determining Natural Capital Costs and Benefits

Scope

Overview

This study identifies and values the natural capital costs of 20 relevant sectors in Qinghai in terms of GDP contribution and environmental damage, and the natural capital benefits for four important ecosystem types in the province in terms of ecosystem services provided and area covered. The sectors cover key industry types such as energy, farming, manufacturing and mining activities; and the ecosystem types present in the region: forests, grasslands, wetlands and deserts. In addition, the study analyses Qinghai's regional policies and Chinese national policies.

Qinghai's regional government has recently established its 13th Five-Year Plan, which contains a wide range of policies that are expected to be accomplished by 2020. The analysis in this study has been conducted for both 2015 and 2020, in order to assess the natural capital implications that two key policies contained in the 13th Five-Year Plan would have in the region: firstly, to increase GDP and secondly, to increase natural environment land coverage . In addition, a qualitative assessment of additional policy targets included in Qinghai 13th Five-Year Plan and China 13th Five-Year Plan was undertaken, allowing the identification of synergies and challenges in achieving all these targets simultaneously and providing opportunities to help achieve these.

Scope Details

Trucost undertook a materiality assessment to identify the 25 most material sectors in Qinghai. Sectors were identified as material if they had a high impact on the environment (high natural capital intensity) and a high contribution to Qinghai's economy (high GDP). GEI then selected the 20 most relevant sectors from that list. GEI selection was based on major industrial sectors and most performed community livelihood practices in Qinghai. Agricultural sectors were selected based on their universality of plantations and their importance especially to Qinghai farmers' livelihood practices. These 20 sectors account for over 34% of the province's 2015 GDP (Qinghai Bureau of Statistics, 2016 a, 2016 b). Table 1 shows the sectors for which the natural capital costs are calculated in the study and the coverage they represent.

TABLE 1. SECTORS FOR WHICH NATURAL CAPITAL COSTS ARE INCLUDED IN THE STUDY

COMPONENT	NO.	SECTOR	SECTOR COVERAGE	AGGREGATED COVERAGE
NATURAL CAPITAL COST	1	Natural gas power generation	0.2%	Represents 34% of Qinghai GDP
	2	Poultry hatcheries	0.1%	
	3	Potato farming	0.5%	
	4	Petroleum refineries	2.6%	
	5	Hydroelectric power generation	3.9%	
	6	Lead ore and zinc ore mining	2.1%	
	7	Wheat farming	0.3%	
	8	Dairy cattle and milk production	0.7%	
	9	Hog and pig farming	0.6%	
	10	Ferrous metal foundries	2.2%	
	11	Flaxseed farming	0.5%	
	12	Bituminous coal underground mining	2.2%	
	13	Crude petroleum and natural gas extraction	4.7%	
	14	Sheep & lamb farming	1.7%	
	15	Primary smelting and refining of non-ferrous metal	8.1%	
	16	Coal power generation	1.7%	
	17	Cattle ranching and farming	1.5%	
	18	Nursery and tree production	0.0%	
	19	Sugar beet farming	0.0%	
	20	Barley farming	0.1%	

SOURCE: TRUCOST AND QINGHAI BUREAU OF STATISTICS (2016 a, 2016 b)

In terms of natural capital benefits, the four predominant ecosystem types were included: forests, grassland, wetlands and deserts. Those ecosystems were selected as they are the four main natural ecosystems in Qinghai and provide a wide range of ecosystem services. The majority of the province's area (80%[1]) is covered by these four types of ecosystems (Qinghai Bureau of Statistics, 2015; Qinghai Bureau of Statistics, 2016 a and 2016 b), giving a good representation of the natural capital benefits occurring in the region. Table 2 highlights the four types of ecosystems and their regional coverage.

TABLE 2. ECOSYSTEM TYPES FOR WHICH NATURAL CAPITAL BENEFITS ARE INCLUDED IN THE STUDY

COMPONENT	NO.	ECOSYSTEM TYPES	COVERAGE
NATURAL CAPITAL BENEFIT	1	Forest	Represents 80% of Qinghai area
	2	Grassland	
	3	Wetland	
	4	Desert	

SOURCE: QINGHAI BUREAU OF STATISTICS (2015) AND QINGHAI BUREAU OF STATISTICS (2016 a, 2016 b)

As mentioned above, the natural capital assessment of costs and benefits was undertaken at different points in time. Table 3 describes the chronological dimension of the study, the corresponding years selected and what they represent.

TABLE 3. CHRONOLOGICAL DIMENSION OF THE STUDY

CHRONOLOGICAL DIMENSION	YEAR	DESCRIPTION
Present	2015	Baseline representing the current status in Qinghai
Future	2020	Policies in Qinghai 13th Five-Year Plan are expected to be achieved

SOURCE: TRUCOST (2016)

In order to assess the future implications on natural capital of the Qinghai 13th Five-Year Plan and the China 13th Five-Year Plan, a set of policies from each were analyzed. Table 4 highlights the selected policies and whether the type of assessment for each was quantitative or qualitative. Two Qinghai regional policies were assessed quantitatively: increase in GDP and increase in natural area. These policies were selected as they capture both the aim of the regional government to provide economic growth but also environmental protection. These policies were assessed quantitatively by using natural capital valuation accounting. This technique allows changes in natural capital costs and benefits to be compared using the same metric. Four other policies from the Qinghai and China five-year plans were briefly assessed qualitatively, and the sectors that would face the greatest challenges in complying with the policies were identified.

TABLE 4. DESCRIPTION OF POLICIES INCLUDED IN THE STUDY

NO.	POLICY INITIATIVE	POLICY PLAN	TYPE OF ASSESSMENT
1	GPD increase - Policy 1	Qinghai 13th Five-year plan	Quantitative
2	Increase in natural area coverage - Policy 2	Qinghai 13th Five-year plan	Quantitative
3	Increase in power generation capacity	Qinghai 13th Five-year plan	Qualitative (briefly)
4	Increase in fossil fuel production	Qinghai 13th Five-year plan	Qualitative (briefly)
5	Decrease in water use per GDP	China 13th Five-year plan	Qualitative (briefly)
6	Decrease in CO_2 emissions per GDP	China 13th Five-year plan	Qualitative (briefly)

SOURCE: TRUCOST (2016)

Method

Method Overview

Trucost used its EEIO model to quantify environmental impacts from industry sectors in physical quantities (for example, tonnes of GHG or cubic meters of water). Trucost's model quantifies the amount of resources used and pollutants emitted per unit of production for more than 500 sectors based on economic interactions between sectors in the economy. For more information on Trucost EEIO model, please refer to Appendix 1.

1 The remaining 20% comprises urban and bare land.

Once the quantification step was completed, Trucost applied natural capital valuations to convert the impacts from physical metrics to financial metrics (Chinese Yuan). Qinghai- and China-specific natural capital factors were applied to value the direct operational impacts for the 20 sectors selected, except in the case of GHG emissions.[2] Indirect impacts hidden within the supply chain were valued by using global average natural capital factors, reflecting that the flow of goods and services occurs not only within China but worldwide.

Please note that Trucost valuation library values impacts in USD$. For the purpose of this report, impacts in USD$ were converted to CNY using a conversion rate of 6.215. This number corresponds to the annual average conversion rate for 2015 from Oanda (2015).

Table 5 provides a summary of the methodology used in this study for the natural capital costs and benefits included in the analysis. The table highlights the EKPIs included in each of these components, and the geographical specificity for the quantification and valuation steps.

TABLE 5. SUMMARY OF THE METHODOLOGY

COMPONENT	SCOPE	EKPI	QUANTIFICATION	VALUATION
NATURAL CAPITAL COST	20 SECTORS	GHG emissions	Qinghai region specific where possible	Qinghai region specific for water use and land use change Country specific for air pollutants, waste and water pollutants Global for GHG emissions
		Air pollutants		
		Water use		
		Waste generation		
		Land use change (Ecosystem services loss)		
NATURAL CAPITAL BENEFIT	4 ECOSYSTEM TYPES	Ecosystem services provided[3]	Qinghai region	Qinghai region

SOURCE: TRUCOST (2016)

Method Details

Natural Capital Costs and Benefits

The monetary valuation coefficients used to determine natural capital costs are provided in table 6. The table shows the impact in economic terms of GHG and air pollutant emissions to the atmosphere, changes in land use, depletion of water, waste generation and discharge of water pollutants. For more information on the valuation approach used to establish these coefficients, please refer to Appendix 2 'Natural capital valuation methodologies'.

TABLE 6: MONETARY VALUATION COEFFICIENTS PER EKPI (COSTS)

GHG	AIR POLLLUTANTS					LAND USE CHANGE	WATER USE	WASTE	WATER POLLUTANTS[4]
	NH_3	SO_2	NO_x	VOCs	PM_{10}				
CNY per t	CNY per t	CNY per t	CNY per t	CNY per t	CNY per t	CNY per ha	CNY per m^3	CNY per t	CNY per t
746	20,419	12,700	14,193	56,212	64,740	1,133	0.5	864	19,625,489

SOURCE: TRUCOST (2016)

The geographical specificity associated with each of these cost-related coefficients is shown in table 7. As it can be seen, most of these coefficients are China specific, while land use change and water use are relevant to Qinghai region. There are key factors influencing land use change and water use valuation coefficients: the types of ecosystems and the levels of water scarcity respectively. Since these two factors can vary significantly within a country, Trucost determined them at a local level, as was the case for Qinghai.

2 This is due to methodological reasons. As the emission of GHGs implies a global increase in temperature in the atmosphere, the impact of those emissions will be global and not local.
3 Ecosystem services provided by forests, grasslands, wetlands and deserts in Qinghai.
4 Average value for a wide range of water pollutants (such as heavy metals, and eutrophying substances).

TABLE 7. LEVEL OF GRANULARITY FOR THE MONETARY VALUATION COEFFICIENTS (COSTS)

GHG	AIR POLLLUTANTS					LAND USE CHANGE	WATER USE	WASTE	WATER POLLUTANTS
	NH_3	SO_2	NO_X	VOCs	PM_{10}				
Global	China	China	China	China	China	Qinghai	Qinghai	China	China

SOURCE: TRUCOST (2016)

The monetary valuation coefficients used to calculate natural capital benefits are shown in table 8. The table shows the benefits in economic terms that are provided by different natural habitats in Qinghai. These valuation coefficients were sourced from Han et al. (2016). Please note that this publication does not contain values specifically for wetlands, and so the valuation for 'Rivers/ Lakes' was used instead in order to ensure the values were specific for Qinghai.

TABLE 8. MONETARY VALUATION COEFFICIENTS PER ECOSYSTEM TYPE (BENEFITS)

FOREST	GRASSLAND	WETLAND	DESERT
CNY per ha	CNY per ha	CNY per ha	CNY per ha
5,253	2,027	11,130	220

SOURCE: HAN ET AL. (2016)

Table 9 shows the geographical specificity for the benefit-related coefficients. As can be seen, Qinghai-specific monetary valuations were employed for all ecosystem types.

TABLE 9. LEVEL OF GRANULARITY FOR THE MONETARY VALUATION COEFFICIENTS (BENEFITS)

FOREST	GRASSLAND	WETLAND	DESERT
Qinghai	Qinghai	Qinghai	Qinghai

SOURCE: TRUCOST (2016)

Policy Scenario

The assessment of natural capital costs and benefits was undertaken for the year 2015 and when the policies are presumed to be achieved in 2020.

Table 10 summarizes two selected policies from the Qinghai 13th Five-Year Plan, named here policy 1 and policy 2. The table also shows the goals required for those policies to be achieved, and the factors that are influenced by those policies in the analysis. By altering those factors, the study was able to reflect the implications of both policies.

In the case of policy 1, the goal states that there should be an annual increase of 7.5% from 2015 to 2020. This leads to a total GDP increase of 43.6% within the period 2015-2020, which has been calculated by using the compound growth rate method. In this study it was assumed that higher GDP implies higher production levels and thus an increase in production value. In particular, it was assumed that GDP and production value were linearly correlated, thus as GDP is expected to grow 43.6%, production value is also expected to grow by 43.6%.

In the case of policy 2, the goal aims to reach certain levels of natural area coverage. In particular, the goal is to achieve 7.5% forest area coverage and 70% grassland area coverage in Qinghai region.

TABLE 10. DESCRIPTION OF POLICY 1 AND 2

POLICY NUMBER	GOAL SUMMARY	GOAL TO BE ACHIEVED	FACTOR INFLUENCED IN THIS ANALYSIS
Policy 1	GDP increase	7.5% annual increase between 2015- 2020	Increase in production value
Policy 2	Increase in natural area coverage	Achieve a 7.5% of forest area coverage in 2020[5]	Increase in ecosystem services provided
		Achieve a 70% of grassland area coverage in 2020[6]	

SOURCE: QINGHAI NDRC (2016)

5 According to Qinghai Bureau of Statistics (2016 a), the status of forests in Qinghai in 2015 is 6.3%.
6 According to Qinghai Bureau of Statistics (2015), the status of grasslands in Qinghai in 2012 is 60%.

Limitations

The methodology has certain limitations, including:

- For determining the natural capital costs and the GDP contribution of the 20 sectors in Qinghai, the regional government sectors had to be mapped to Trucost sectors. However, the level of granularity of the sectors mapped was not always the same.
- Valuation coefficients for rivers/lakes were used to value wetlands in Qinghai, as data was not available for this type of ecosystem. Since wetlands are a very complex and rich ecosystem, providing a high degree of ecosystem services (Costanza et al., 2014), the value obtained in this study for the benefits provided by wetlands is a conservative number and thus can potentially underestimate the real benefits provided by this habitat.
- The production value of the 20 sectors is estimated as a share of the total production value for China. The share is calculated based on Qinghai's contribution to national product output from these sectors, for example: product output quantity and resource availability.
- This study does not assess the natural capital costs for the entire Qinghai economy, but is limited to 20 sectors which together account for 34% of Qinghai's GDP in 2015.
- In policy 1, production value is assumed to increase in the same degree as GDP. Thus, production efficiency improvements are excluded from the analysis.
- In policy 2, the increase of grassland area between 2015 and 2020 is estimated based on the area in 2012, assuming equal annual growth rate between 2012 and 2020.
- The combination of policy 1 and 2 does not take into account the land input from forest, grassland, wetlands and deserts that is required to generate higher production value and thus sustain economic expansion.
- Ecosystem services provided by deserts were included in the valuation of the natural capital benefits provided in Qinghai region. However, as the degree of ecosystem services provided by deserts is low when compared to other terrestrial biomes, the impacts from the loss of these services are excluded when determining land use change impacts due to the sectors' supply chain. The impacts from the loss of ecosystem services from deserts due to the sectors' direct operations is included in the analysis.

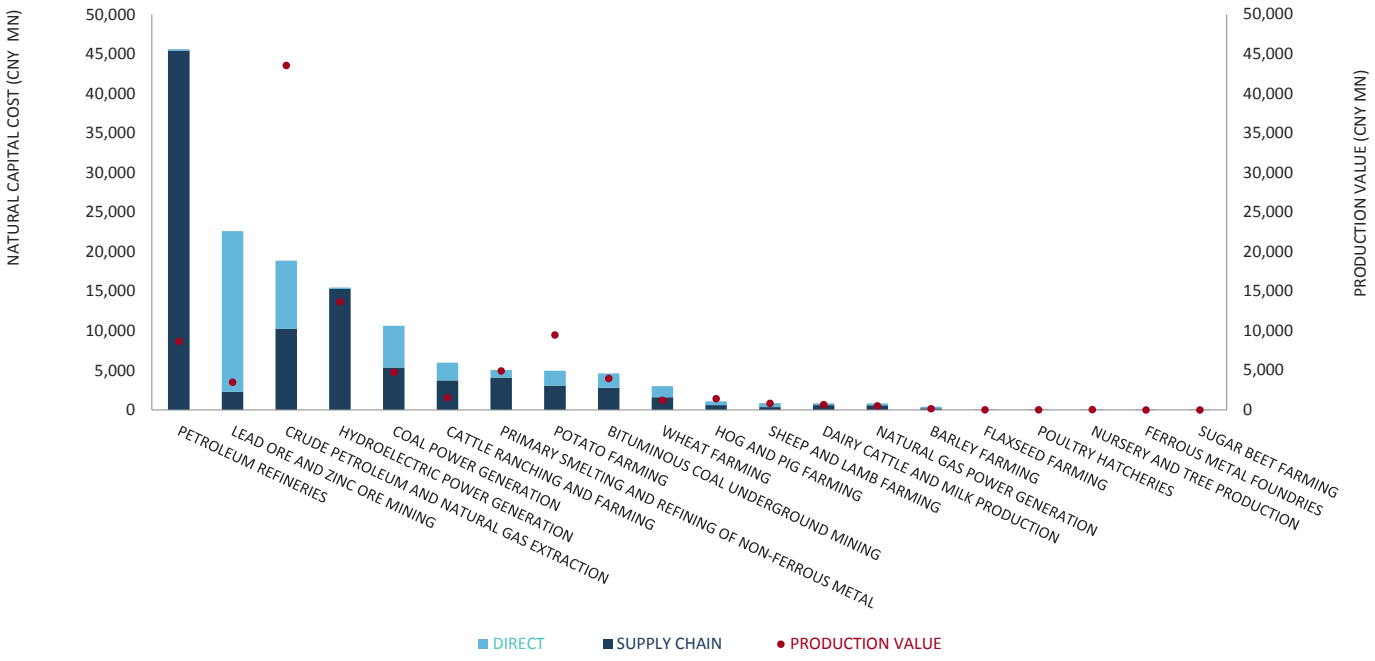
Results

Present Situation

Natural Capital Costs

The total natural capital cost of Qinghai's 20 selected sectors was CNY 140,773 million in 2015, over 40% higher than the production value that these sectors generated in 2015. Figure 2 shows the natural capital costs and the production value for each for the 20 sectors in the analysis. To provide additional information, natural capital costs are broken down into direct operations and supply chain. Costs from direct operations occur within Qinghai region, while costs from the supply chain occur worldwide.

FIGURE 2. NATURAL CAPITAL COSTS (DIRECT AND INDIRECT) AND PRODUCTION VALUE PER SECTOR. ORDERED BY NATURAL CAPITAL COST



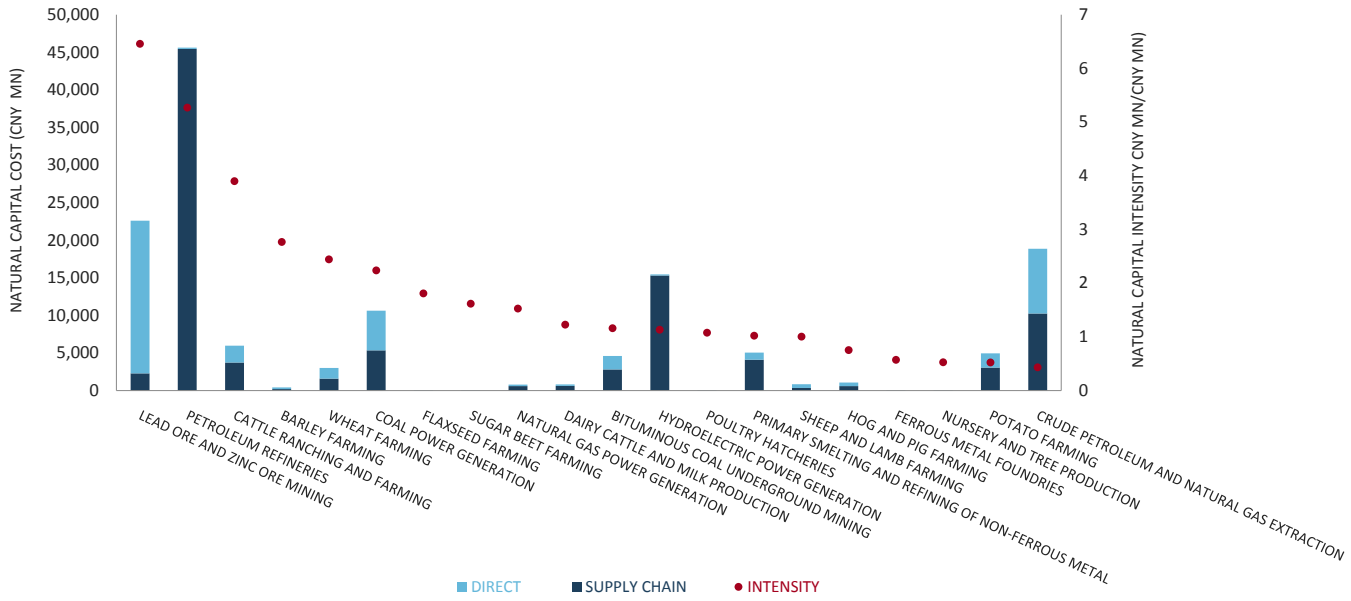
SOURCE: TRUCOST (2016)

As can be seen in the figure, the sectors with the highest natural capital costs are mainly associated with the energy sector (except mining). The hotspots in terms of natural capital costs are, in order of significance, petroleum refineries, lead ore and zinc ore mining, crude petroleum and natural gas extraction, hydroelectric power generation and coal power generation. These sectors together contribute more than 80% of the total natural capital costs. In terms of EKPIs, GHG emissions account for the majority of the costs (73%), followed by water pollutants (17%), land use (8%), with the remaining EKPIs contributing approximately 2%.

In general, across the 20 sectors most of the costs come from the supply chain (68%) due to impacts associated with upstream production activities and raw materials extraction. The direct operational impacts of the sectors account for 32% of the total natural capital costs. There are some sectors for which the natural capital costs are relatively low due to the low production levels of those sectors in Qinghai region. For example, flax seed farming, poultry hatcheries, nursery and tree production, ferrous metal foundries and sugar beet farming.

Figure 3 highlights the natural capital costs and the natural capital intensities ordered from higher to lower intensity.

FIGURE 3. NATURAL CAPITAL COSTS (DIRECT AND INDIRECT) AND NATURAL CAPITAL INTENSITY PER SECTOR. ORDERED BY NATURAL CAPITAL INTENSITY



SOURCE: TRUCOST (2016)

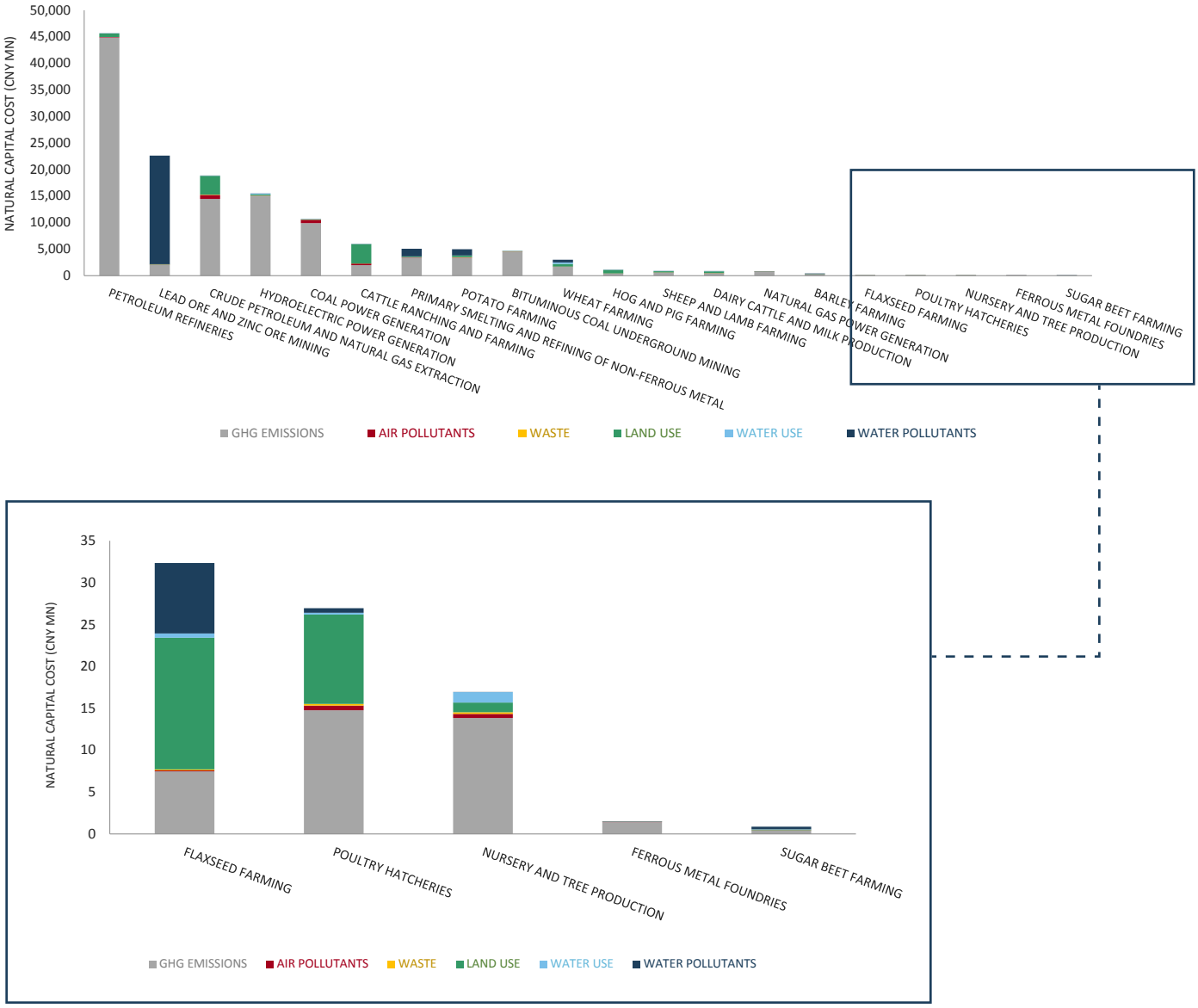
As shown in the graph, sectors with the highest intensities are lead ore and zinc ore mining, followed by petroleum refineries and cattle ranching and farming.

Lead ore and zinc ore mining have a high intensity mainly due to their water pollution impacts (91% of the total cost) of mining direct operations. Lead and zinc are heavy metals with a high toxic potential that can significantly alter water quality. Environmental disasters have already occurred in some regions of China, where the local population's health has been severely affected by pollution of water sources from lead and zinc waste coming from mining activities (Radio Free Asia, 2006). As mentioned in Zhang et al. (2012), China is one of the main global producers of lead and zinc. As a result, lead and zinc have impacted water, soil and the biota during mining operations, causing environmental and human impacts in China (Zhang et al., 2012).

The petroleum refineries sector's largest impact is from GHG emissions (98% of the total cost) which mainly occur in its supply chain. In the case of cattle ranching and farming, most of its impacts are associated with land use change (61% of the total cost). High areas of land are normally required to raise cattle, particularly in extensive farming systems. The beef cattle industry in the Northwest of China, including provinces such as Qinghai, Inner Mongolia and Xinjiang, has traditionally been characterised by the use of extensive grazing systems (Waldron et al., 2015).

Figure 4 (overleaf) provides the natural capital costs split by EKPI – GHG emissions, air pollutants, waste, land use, water use, and water pollutants – for each sector.

FIGURE 4. NATURAL CAPITAL COSTS SPLIT BY EKPI PER SECTOR



SOURCE: TRUCOST (2016)

GHG emissions, the most relevant natural capital impact identified in the study, is the largest cost for energy related industries, as fossil fuels are normally the raw material used in the production process. This is the case for the sectors crude petroleum and natural extraction, coal power generation and natural gas power generation.

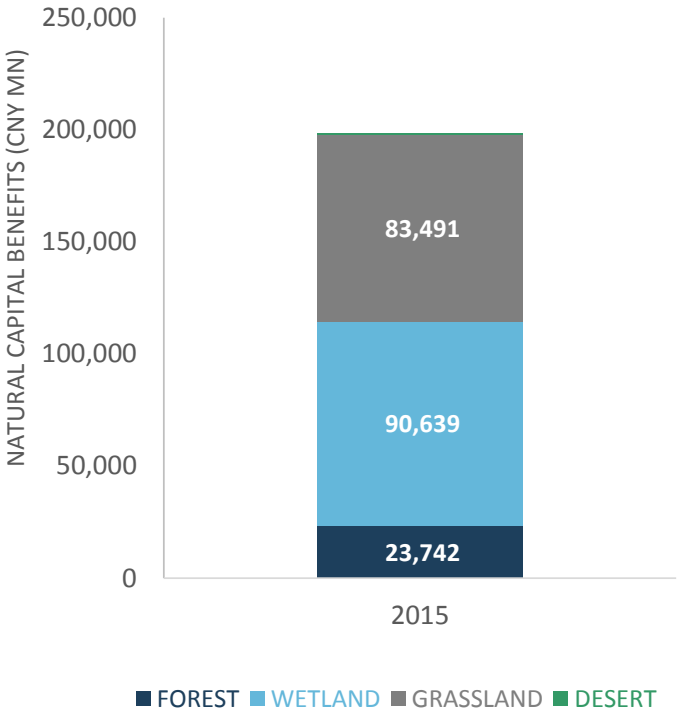
Water pollutants were the second most relevant natural capital cost in this study, and are mainly associated with mineral related activities such as lead ore and zinc ore mining, primary smelting and refining of non-ferrous metals, and farming activities such as potato farming and wheat farming. In the case of farming, its impacts are mainly associated with the direct operations of the sector, in particular fertilizers application. When fertilizers are applied in excess of the plant's needs, nitrogen and phosphorus run off the field into water bodies, leading to impacts on human health and ecosystems.

Land use is an important natural capital cost for several farming sectors and is the most material EKPI for sectors such as cattle ranching and farming, hog pig farming or flaxseed farming. In the case of animal farming (cattle, pig, dairy farming), large areas of land are not only needed to raise the animals but to produce feed crops. The total area assigned to produce animal feed crops represents 33% of total arable land on the planet (FAO, 2006).

Natural Capital Benefits

Natural capital benefits from forest, wetland, grassland and desert areas in Qinghai were determined for 2015 using the data that appears in Section 2. The results split by ecosystem type are provided in figure 5 and expressed in CNY million per year.

FIGURE 5. NATURAL CAPITAL BENEFITS FROM ECOSYSTEMS IN QINGHAI



SOURCE: TRUCOST (2016)

As can be seen from the graph, most of the benefits are associated with wetlands. Even if the surface area of wetlands is 80% lower than for grasslands (8,143,600 ha versus 41,188,441 ha), the natural capital benefits provided are higher. This is because wetlands provide a higher degree of ecosystem services than forests, and this is reflected in the monetary valuation coefficients presented in table 8. As shown in that table, the ecosystem services provided by wetlands are valued at CNY 11,130 per ha versus CNY 5,253 per ha provided by forests.

Table 11 shows the types of ecosystem services that are included in the valuation of natural capital benefits. The table also describes the subtypes of ecosystem services considered and provides examples of them. Supporting ecosystem services were not included in this analysis to avoid double counting.

TABLE 11. NATURAL CAPITAL BENEFITS AND ECOSYSTEM SERVICES

NATURAL CAPITAL BENEFITS			
ECOSYSTEM SERVICE TYPE	**SUBTYPE**	**DESCRIPTION**	**EXAMPLES**
Provision	Food production	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
	Raw material production	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel or fodder.

Cont.

NATURAL CAPITAL BENEFITS			
ECOSYSTEM SERVICE TYPE	SUBTYPE	DESCRIPTION	EXAMPLES
Regulation	Gas regulation	Atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SOx levels.
	Climate regulation	Global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Greenhouse gas regulation, DMS production affecting cloud formation.
	Hydrology regulation	Hydrological flows.	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation.
	Waste regulation	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
Cultural	Aesthetic landscape provision	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

SOURCE: ADAPTED FROM HAN ET AL. (2016) AND COSTANZA ET AL. (1997)

Policy Scenario Analysis

This section provides results for the policy scenario analysis by looking at the changes derived from two policies in Qinghai in terms of the natural capital costs and benefits occurring in the region. This is done by comparing the situation in 2015 with a potential future situation in which those two policies are achieved in 2020. The section starts providing the results for the two policies independently, and then it combines them to provide a holistic overview of the natural capital implications for Qinghai derived from those initiatives. All values that appear in the report are expressed in 2015 terms. Thus, the values for 2020 that appear in this section were converted to 2015 prices by using inflation and/or discount rates. The inflation rate used was sourced from the World Bank (2015) and corresponds to China average inflation rate from 2010 to 2015, as 2015 is the most updated inflation rate available. The discount rate used corresponds to 3% as recommended by the USIAWG (2013).[7]

Policy 1

Policy 1 is focused on the expansion of GDP in Qinghai for the following years. This policy is in line with the goal established by the Chinese Government to promote the economic expansion of the country. The goal established is to achieve an annual increase in GDP of 7.5% in 2015-2020 (Qinghai NDRC, 2016).

Table 12 shows information on the number of sectors included in the assessment and the production value in 2015 and in 2020 when policy 1 is expected to be met. As GDP is assumed to be linearly correlated with production value, production value will increase in line with the GDP target; this is by 43.6%.

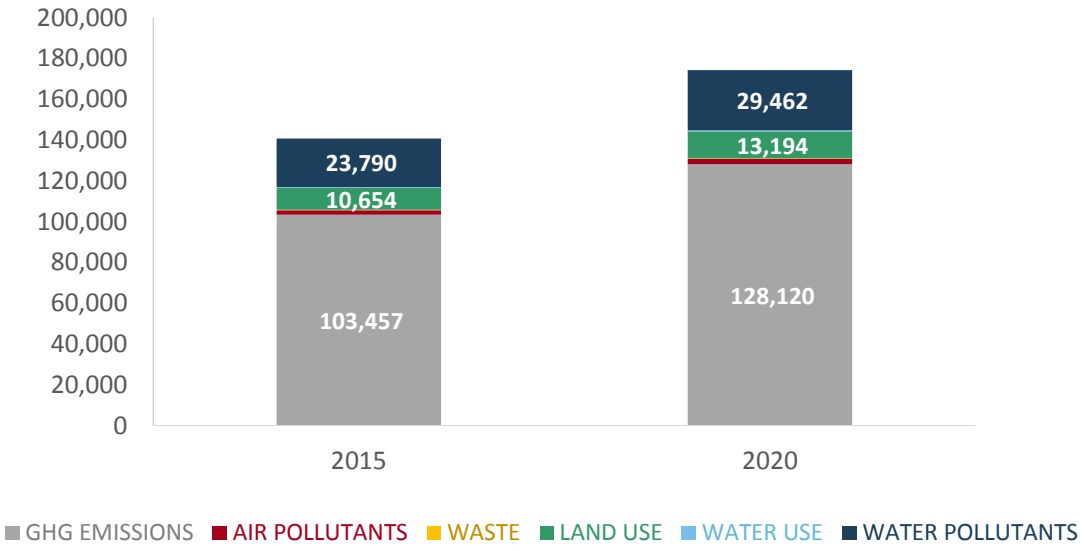
TABLE 12. NATURAL CAPITAL COSTS EVOLUTION UNDER POLICY 1

NATURAL CAPITAL COSTS		
ITEM	2015 – PRESENT	2020 – POLICY 1 ACHIEVED
Sectors in scope	20 sectors	20 sectors
Production value for Qinghai (CNY mn)	98,966	122,559

SOURCE: TRUCOST AND NATIONAL BUREAU OF STATISTICS OF CHINA (2016)

7 The annual 7.5% GDP increase was assumed to incorporate inflation (nominal GDP). Thus, in policy 1 2020 values were expressed in 2015 terms simply by discounting. In Policy 2, 2020 values were expressed in 2015 terms by inflating and discounting.

FIGURE 6. CHANGES IN NATURAL CAPITAL COSTS FROM 2015-2020 UNDER POLICY 1



SOURCE: TRUCOST (2016)

As can be observed in figure 6, there is an increase in natural capital costs from 2015 to 2020 for all the EKPIs in the analysis: GHG emissions, air pollutants, waste, land use, water use and water pollutants. This is due to the higher economic activity for all the sectors resulting from an increase in GDP. The natural capital costs in 2015 are CNY 140,773 million and in 2020 they are CNY 174,332 million. This implies that there are over CNY 30,000 million additional natural capital costs due to the implementation of policy 1. The relative contribution of each EKPI remains constant from 2015 to 2020, with GHG emissions the main natural capital cost (73%), followed by water pollutants (17%), land use (8%) and air pollutants (2%). Together waste generation and water use represent approximately 1% of the natural capital cost in both time horizons.

Policy 2

Policy 2 aims to increase the coverage of natural area in Qinghai from two key ecosystems in the region: forest, which provides a high level of ecosystem services such as carbon sequestration, and grassland, which is the predominant ecosystem in the region. The rationale behind this policy is to ensure that regional land conservation aligns with the national target of enhancing land conservation and afforestation that appears in China 13th Five-year plan.

Table 13 describes the area coverage per type of ecosystem in 2015 and in 2020 when policy 2 is expected to be achieved. The increase in forest is 1.2% (7.5% - 6.3%), in grasslands is 12.6% (70% - 57.4%) and in wetlands and deserts is 0%. The area for wetlands and deserts is maintained constant in the analysis as is not affected by policy 2.

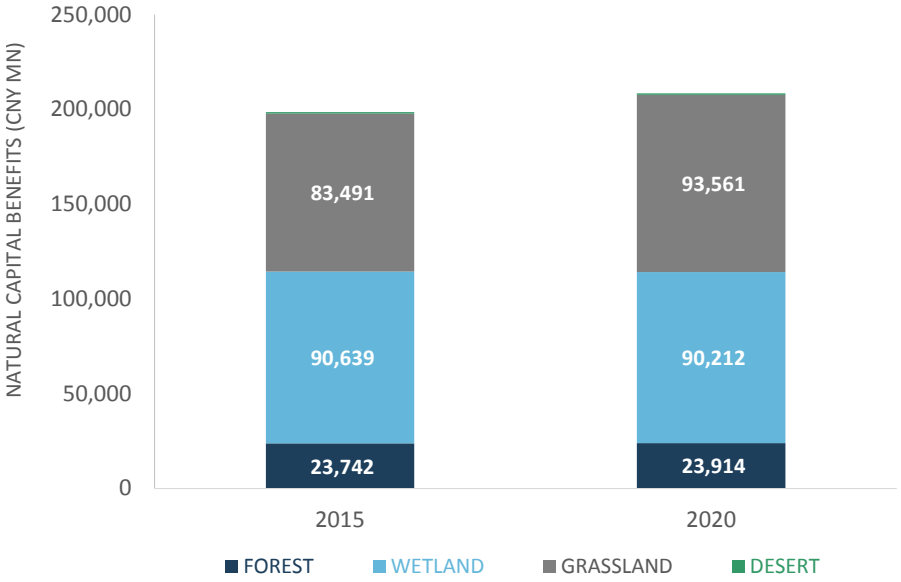
TABLE 13. NATURAL CAPITAL BENEFITS EVOLUTION UNDER POLICY 2

NATURAL CAPITAL BENEFITS		
ECOSYSTEM TYPE	AREA COVERAGE	
	2015 – PRESENT	2020 – POLICY 2 ACHIEVED
Forest	6.3 %	7.5 %
Grassland	57.4 %	70.0 %
Wetland	11.4 %	11.4%
Desert	4.9%	4.9%

SOURCE: DATA FOR 2015 ADAPTED FROM QINGHAI BUREAU OF STATISTICS (2016 a, 2016 b) AND (2015). DATA FOR POLICY 2 FROM QINGHAI NDRC (2016)

Figure 7 provides the results for the changes in natural capital benefits from 2015 until 2020, when policy 2 is expected to be achieved.

FIGURE 7. CHANGES IN NATURAL CAPITAL BENEFITS FROM 2015-2020 UNDER POLICY 2



SOURCE: TRUCOST (2016)

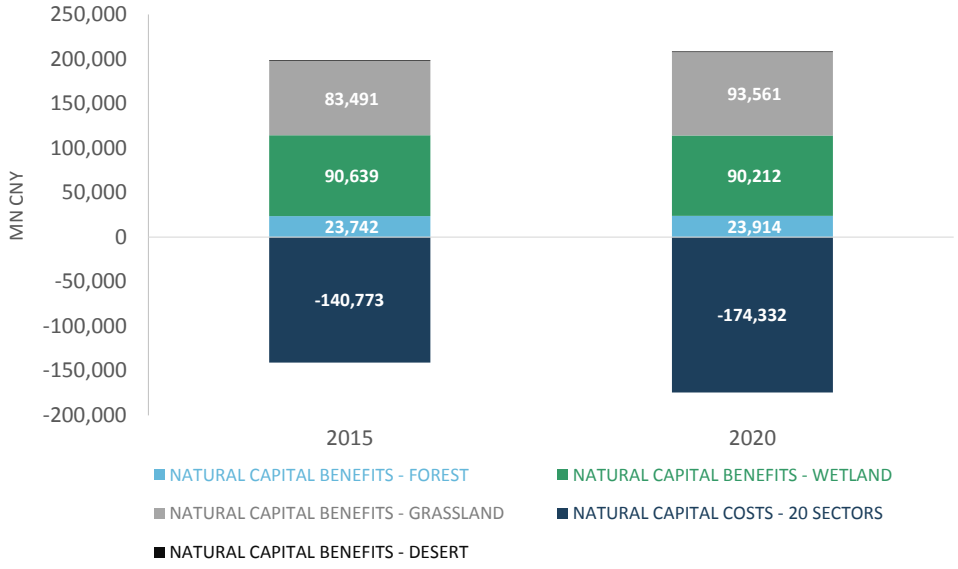
As can be seen in the table, there is an increase in natural capital benefits due to policy 2. In particular, policy 2 leads to an increase in natural capital benefits of almost CNY 10,000 million. This is because there is a larger area of natural land, and thus the ecosystem services provided are higher. In 2015 the area under forest, grasslands, wetlands and deserts was 57,356,484 ha in total (adapted from Qinghai Bureau of Statistics 2016 a, 2016 b and 2015). In 2020, the total area for those four ecosystems could be 62,596,897 ha; thus there are over 5,000,000 additional hectares due to policy 2. As the region has an extensive area of bare land, that could be the area to be restored to introduce the new grassland and forest.

Combination of Policy 1 and 2

After the natural capital implications from policy 1 and 2 were determined, the results were consolidated to identify the net result when combining those two policies.

Figure 8 provides the consolidated results of the analysis, obtained when merging the natural costs from policy 1 and the natural capital benefits from policy 2.

FIGURE 8. STATUS IN 2015 AND STATUS IN 2020 UNDER POLICY 1 AND 2 COMBINED



SOURCE: TRUCOST

When combining both, the net result is + CNY 57,869 million in 2015 and + CNY 34,122 million in 2020. This implies a loss of CNY 23,747 million from 2015 to 2020 due to the two Qinghai regional policies. Please note that these results represent a partial view of the natural capital costs in Qinghai, focusing on the top 20 sectors which represent 34% of Qinghai GDP. This implies that the total natural capital cost occurring in the region would be higher in reality, and this could potentially lead to a negative net result both in 2015 and 2020 if those costs were included.

If both policy 1 and 2 are achieved in 2020:

- The natural capital costs will increase by almost 24% compared to 2015 levels
- The natural capital benefits will increase by 5% compared to 2015 levels

It should be noted that there are additional targets stated in the Qinghai 13th Five-year plan (Qinghai NDRC, 2016) and China 13th Five-year plan (National Development and Reform Commission, 2016) that can be challenging to be achieved jointly with the targets already presented under policy 1 and 2. Some of those additional targets to be accomplished by 2020 are:

- Increase in power generation capacity: applicable to hydro and coal power generation
- Increase in fossil fuel production: applicable to coal, crude oil and natural gas production
- Reduction of CO_2 emissions / 10,000 CNY GDP: applicable to all sectors
- Reduction of water use / 10,000 CNY GDP: applicable to all sectors

If those additional targets are taken into account together with the GDP and area targets of policy 1 and 2, some challenges will arise as they impose the need for decoupling. The sectors that will face the greatest challenges could be:

- Sectors that are expected to increase capacity while lowering resource use and emissions intensity (power generation sectors such as hydroelectric power generation and coal power generation)
- Sectors that are expected to increase production levels while lowering resource use intensity and emissions intensity (extractive sectors such as bituminous coal underground mining and crude petroleum and natural gas extraction)
- Carbon-intensive sectors (for example energy sectors)
- Water-intensive sectors (for example agricultural sectors)

As mentioned in UNEP (2011), “decoupling is feasible, and indeed is already happening, but further sustainability-oriented innovations are urgently required to enable decoupling to support sustainable development more effectively”.

The section on potential steps describes some mechanisms for alleviating these decoupling challenges and identifies opportunities to help achieve the goals.

Conclusions

Natural Capital Costs

- The top 20 most relevant sectors in Qinghai were identified based on their GDP contribution to the region and their natural capital intensity. The 20 most relevant sectors contain primarily:
  - » Energy-related sectors (for example coal power generation)
  - » Farming sectors (for example cattle ranching and farming)
  - » Mining sectors (for example bituminous coal underground mining)
  - » Manufacturing sectors (primary smelting and refining of non-ferrous metal)
- Lead ore and zinc ore mining was found to be the sector with the highest natural capital intensity when analysing the top 20 most material sectors in Qinghai. This is mainly due to the high impacts from water pollution as part of the direct operations of the sector.
- Petroleum refineries was found to be the sector with the highest natural capital cost, as the sector has both a high natural capital intensity (second highest) and high production levels in Qinghai.

Natural Capital Benefits

- Qinghai's main natural ecosystem types are grasslands, wetlands, forest and deserts. In 2015, these represented approximately 60%, 10%, 6% and 5% respectively. Of these ecosystems, wetlands provide the higher level of natural capital benefits, as it is a very complex habitat that provides a wide range of ecosystem services such as waste regulation and aesthetic landscape provision. Forests are the second most valuable ecosystem, as this habitat provides crucial ecosystem services such as climate regulation, hydrology regulation and raw materials.

Policy Assessment

- Qinghai region has set a new policy program under the name of Qinghai 13th Five-Year Plan which contains a wide range of goals to be accomplished by 2020. Some of those goals aim to decrease environmental impacts – such as the intensity goals for GHG emissions and water, or the increase in natural areas – while others aim to expand production levels in the region, such as the increase in GDP.
- This study is focused on quantifying the implications of two selected policies from this regional plan: the increase in GDP – named as Policy 1 – and the increase in natural areas – named as Policy 2. The study determined that if policy 1 is achieved in 2020 this would imply additional natural capital costs derived from higher production levels in the region. Specifically, the implementation of policy 1 would result in CNY 33,558 million extra costs. On the other hand, the study determined that achieving policy 2 in 2020 would lead to additional natural capital benefits due to the additional area dedicated to forest and grasslands habitats. In particular, policy 2 implementation would lead to CNY 9,811 million extra benefits. When combining both policies, there is a net increase in natural capital costs of CNY 23,747 million from 2015 to 2020, suggesting that when looking at those two policies together, natural capital would be negatively affected. To compensate for this loss, Trucost recommends that additional policies to encourage environmental protection or sustainable economic expansion are designed.
- In order to provide a wider picture, the study qualitatively reviewed additional goals that Qinghai is promoting as part of its 13th Five-Year Plan and several national targets published in China 13th Five-year plan. Some of those targets include the increase in power generation capacity (applicable to hydro and coal power generation), the increase fossil fuel production (applicable to coal, crude oil and natural gas production) and the decrease in carbon emissions and water use per GDP generated (applicable to all sectors). Consequently, the sectors that may face the greatest risks and challenges are:
  - » Sectors that are expected to increase capacity while lowering resource use and emissions intensity (for example hydroelectric power generation and coal power generation)
  - » Sectors that are expected to increase production levels while lowering resource use intensity and emissions intensity (for example bituminous coal underground mining and crude petroleum and natural gas extraction)
  - » Carbon-intensive sectors (for example energy sectors)
  - » Water-intensive sectors (for example agricultural sectors)

Potential Steps

This study includes potential steps to help policy makers prioritize environmental protection and ensure the sustainable development of Qinghai region:

- Governments usually develop a portfolio of policy targets. Identifying potential challenges between sets of targets and providing solutions is key to ensure they can be achieved together.
  - » In the Qinghai 13th Five-year plan potentially challenging government goals were found, such as goals that promote economic expansion and environmental protection. The increase in production levels on one hand and the increase in natural areas on the other hand is an example of a potential future challenge. Similarly, stimulating the increase in GDP in one hand, and the decrease of resource use and emissions intensity on the other hand, is another example of a potential challenge.
  - » The government could possibly provide guidance and solutions to help the industry face those challenges and ultimately achieve the desired decoupling. For example, if GDP growth is promoted by the Qinghai government as well as the decrease in resource use and emissions intensity (water use and GHG emissions respectively), additional policies that incentivize resource efficient production and the use of renewable energies may be beneficial to ensure those goals can be achieved, and ultimately promote sustainable development in the region. These additional policies could for example include subsidies to access affordable clean technology.
- Qinghai government could possibly engage with highly polluting sectors to raise awareness of the risks and opportunities derived from natural capital. Creating the structure to promote knowledge transfer between the public and private sector, as well as the coordination between those may help the transition to a low carbon economy and Qinghai's sustainable development overall.
- Qinghai government could possibly explore the economic and natural capital implications of future development plans in more depth. This could be done by using natural capital accounting as a supplement to traditional GDP measures, an approach that is already being piloted by many local governments in China. In addition, quantifying the overall effects and dynamics of various policies together could help the government identify potential constrains and priorities for policy design and implementation.
- Government development of science-based targets could also help achieve sustainable development and the transition of Qinghai towards a green economy. While science-based targets have been mainly focused so far in reducing GHG to keep the global temperature increase below 2 degrees Celsius, these types of targets can also be applied to critical resources that support economic growth such as land and water use (WRI, 2016).
- Finally, additional research may be helpful to increase the scope of the study and to provide additional insight for policy makers. For example, including further sectors from Qinghai economy could provide a more complete picture of the natural capital impacts in the region and identify other polluting sectors for engagement. In addition, expanding this first pilot to other important regions in China, as well as delivering an enhanced tool could allow GEI to further support governments in policy decision making, with the ultimate aim of protecting the environment.

Appendix 1. Trucost EEIO Model

The purpose of the Trucost EEIO model is to quantify the economic consequences of natural capital dependency. Environmental impacts directly attributable to a business are calculated according to Trucost's Environmental Matrix that contains environmental intensities per unit of output, and then modelled through the economy using a customised environmentally extended input-output model. Trucost has been collecting environmental data since 2000, and is therefore able to test this model based on 12 years' of data on quantitative environmental disclosures from thousands of companies with which analysts engage annually.

TABLE 14. COMPONENTS OF THE TRUCOST EEIO MODEL

COMPONENT	DESCRIPTION
INDIRECT MODEL	INPUT-OUTPUT (IO) FACTORS IO factors for the flow of goods and services between sectors are created from the U.S. bureau of economic analysis benchmark make and use tables.
DIRECT MODEL	ENVIRONMENTAL MATRIX The environmental impacts of sectors are calculated using country-specific impact factors. Market-traded commodities extracted and water resources are measured at a local level.

SOURCE: TRUCOST (2016)

Indirect Model

Indirect or supply chain impacts are calculated according to Trucost's indirect model. This is constructed from supply and use tables published by the United States Department of Commerce, Bureau of Economic Analysis (BEA). Input-output tables are created detailing the ratio of expenditure from one sector with every other sector of the economy, termed "intermediate demands" of 531 sectors. It is largely due to this level of detail that Trucost has chosen to use the U.S. economy as a proxy for the world economy as a starting point for the creation of its indirect model. Additionally, the U.S. economy has the advantage of being highly diversified so that all extracted commodities/resources can be included.

However, some sectors which are important from an environmental perspective, such as power generation, are highly aggregated, and the U.S. BEA data have insufficient detail on many sectors within the agricultural industry. In these cases, Trucost has disaggregated the input-output tables proportionally. For example, power generation is represented by seven separate sectors within the Trucost model. Over the past six months, Trucost has further extended the indirect model to create indirect input-output factors for an additional 80 sectors, as well as incorporating life cycle analysis and process benchmark data. Finally, the indirect model is refined by disclosures to Trucost from its universe of over 4,500 companies which is collected through an annual engagement program.

Direct Model

Each sector within the environmental matrix contains an average impact per dollar of output for over 100 impacts which are derived from government, life cycle assessment and academic data. Trucost tests this data against the many thousands of disclosures it collects from companies during the annual engagement program.

Indirect Model Outputs and Externalities Covered

Trucost's EEIO outputs cover over 100 environmental impacts which can be condensed into 6 high-level EKPIs covering the major categories of unpriced natural capital consumptions: water use, greenhouse gas emissions (GHGs), waste, air pollution, water pollution, and land use. These environmental impacts can be re-classified into other categories. These environmental impacts can be expressed in physical units (e.g. m^3, t, ha) or in monetary units.

Indirect Model Strengths and Weaknesses

IO modelling assumes generic flows behind sectors, as described in the indirect model above. On a global basis, this can be adjusted using multi-regional IO modelling, or a hybrid approach.
Multi-regional IO modelling adjusts for trade between regions to estimate embedded impacts in products more accurately.

Trucost recommends adopting a hybridised approach to adjust for regional variations in environmental impacts. This is because single region IO models have greater granularity: Trucost's IO model includes 531 sectors whereas multi-regional IO models usually include 80 sectors.

Appendix 2. Natural Capital Valuation Methodologies

What is Being Valued?

The monetary value placed on an environmental good or service can reflect a number of aspects. The market value of timber, for example, reflects only its value as a commodity and an input to another process. However, this typically does not reflect its true value to society and human well-being. Forests, for example, provide a number of essential ecosystem services such as global climate regulation and local water regulation. When market prices do not include a valuation of these services, forests could be managed unsustainably leading to future environmental degradation and resource constraints. The monetary values of ecosystem goods and services and environmental impacts that are subsequently calculated in this study represent the contribution of that good, service or impact to human well-being. Constituents of well-being outlined in the Millennium Ecosystem Assessment include the basic materials needed for a good life, health, good social relations, security as well as many other aspects (Reid et al, 2005). These values reflect the quality and quantity of environmental goods and services provided and also capture aspects of risk; for example, the value of water can take into account the scarcity of water in a specific region.

What Do These Values Mean?

The monetary value that is placed on environmental goods and services demonstrates that there is significant value gained from these goods and services that is not captured in traditional financial markets. The monetary values mean that companies, governments and other key stakeholders such as investors can start to take the environment into account in normal decision-making processes, and compare these to other impacts in monetary terms. Natural capital valuation methodologies applied in this study are outlined in the following sub-sections.

Trucost's Valuation Framework

Trucost's valuation framework builds on an approach proposed by Keeler et al. (2012). The approach follows a four-step process which is outlined in the table below.

TABLE 15: STEPS TAKEN IN TRUCOST'S VALUATION FRAMEWORK

VALUATION FRAMEWORK STEPS	EXAMPLES
Identify actions and beneficiaries of interest	Local communities or users of specific natural resources
Identify shared physical characteristics of the biophysical and economic models	The identification of the attribute you are valuing, such as the changing concentration of pollutants, or change in water clarity
Select appropriate biophysical models	The identification of how the changing biophysical conditions affect the selected beneficiaries. For instance, how the changing concentration of pollutants reduces life expectancy and quality of life, measured in terms of disability adjusted life years (DALY)
Select appropriate economic models	Selecting the appropriate monetary valuation method to value the change in biophysical conditions, such as the value of a life year (VOLY) to value human health impacts

SOURCE: ADAPTED FROM KEELER ET AL. (2012)

The following steps highlight how the approach described above can be applied to assign monetary values to the impacts on human health and ecosystems resulting from increasing chemical concentrations in the atmosphere due to the use of pesticides:

i. The first step involves measuring changes in physical conditions, such as an increase in the concentration of a pollutant in the atmosphere, land, or water.

ii. The second step requires biophysical modelling of the impacts caused by changing physical conditions. This includes identifying factors such as the endpoint of pesticides in the environment, for example human beings, and quantifying the change in the biophysical indicator that is to be valued, for example the change in the quality of human health. This is

measured by the change in disability adjusted life years (DALYs) and can be caused by the ingestion or inhalation of pesticides. Another endpoint for pollutants could be terrestrial ecosystems, and the quantification of the subsequent biophysical change is its effect on biodiversity, measured in terms of the potentially disappeared fraction of species (PDF).

iii. The final step involves the economic modelling component of the valuation. This includes the identification of the final recipient of the impact, such as local populations who are negatively impacted by ingesting or inhaling pesticides, and then selecting an appropriate valuation technique to monetize the change in biophysical conditions. In this instance, Trucost uses the value of a life year (VOLY) to assign monetary values to the change in human health. For the effect on ecosystems in this example, Trucost values the loss of ecosystem services resulting from the impact on biodiversity and the decreased functioning of those ecosystems.

In general, Trucost assesses the change in the quality of human health by measuring disability adjusted life years, or DALYs, and monetizes the impacts by using a global average value for the value of a life year (VOLY). The DALY quantifies the burden of disease on human populations and can be thought of as one year of healthy life lost. The measure includes both the years of life lost due to illness (mortality) and the years of healthy life lost due to disability (morbidity). The method used to calculate the VOLY uses a willingness-to-pay (WTP) approach, which elicits values from society based on changes in factors such as reduced income due to ill health, the pain and discomfort caused, as well as decreased life expectancy.

The table below provides the EKPIs included in the analysis and the scope of the valuation for each of these. The EKPIs comprise natural capital costs from GHG emissions, air pollutants, water pollutants, water use, waste and land use change, as well as natural capital benefits from ecosystem services provided by the land.

TABLE 16. EKPI AND SCOPE OF THE VALUATION

COMPONENT	EKPI	SCOPE OF THE VALUATION
Natural Capital Cost	GHG emissions	Multitude of impacts, including but not limited to, changes in net agricultural productivity, human health and property damages from increased flood risk.
Natural Capital Cost	Air pollutants	The GHGs considered in this analysis include carbon dioxide, methane and nitrous oxide. The social cost of carbon, in 2015 CNY, used in this study is CNY 746 per tonne CO_2 (USIAWG, 2013).[7]
Natural Capital Cost	Water pollutants	Water pollution captures impacts from: 1) The emissions of organic substances, inorganic substances and heavy metals to water (except eutrophying substances). The valuation of those includes impacts on ecosystems and/or human health. 2) The emission of nitrogen, nitrates, phosphates and phosphorus to water coming from fertilizers sources. The valuation includes impacts on human health and the increase of water treatment costs from eutrophication.
Natural Capital Cost	Water use	The water use valuation includes the impacts on human health from malnutrition and lack of domestic water, and the impacts on ecosystems from a change in the potentially affected fraction of species.
Natural Capital Cost	Waste	Impacts due to solid waste sent to landfill or incineration. These impacts include GHG emissions (methane), air pollutants, leachate and the disamenity effects of the waste management site.
Natural Capital Cost	Land use change (Ecosystem services lost)	Ecosystem services lost from the conversion of natural ecosystems resulting from human activities (for example farming, mining or manufacturing activities). Trucost has calculated the country-specific distribution of several global ecosystems, as well as the global average value for the ecosystem services each one provides. This allows Trucost to calculate the average ecosystem value, per hectare, in each country.[8]
Natural Capital Benefit	Ecosystem services provided	Ecosystem services provided by the land when its natural status is maintained, avoiding its degradation due to human activities.

SOURCE:TRUCOST (2016)

7 According to USIAWG (2013), 'the Social Cost of Carbon is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year'.
8 The assumption that all ecosystem services are lost regardless of the type of industrial activity, probably overstates the mean value.

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