TEEB Implementation in China: "Promoting biodiversity and sustainability in the agriculture and food sector project"

A background review of agriculture and biodiversity in China

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List of Acronyms

BIOFIN	Biodiversity Finance Initiative
CAS	Chinese Academy of Sciences
CBD	Convention on Biological Diversity
CMA	China Meteorological Administration
COP	Conference of the Parties
CPC	Communist Party of China
ESMERALDA	Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
INDC	Intended Nationally Determined Contribution
IPBES	Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services
MEP	Ministry of Environmental Protection
NBSAP	National Biodiversity Strategy and Action Plan
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation
WWF	World Wildlife Fund

Executive Summary

1. BACKGROUND

China has achieved sustainable economic growth since 1978 when it moved from a closed, centrally planned system to a more market-oriented one. China's reforms started with the phaseout of collectivized agriculture, which was followed by the steady liberalization of prices, fiscal decentralization, increased autonomy for state enterprises, growth of the private sector, stock markets and a modern banking system, and opening to foreign trade and investment. The efficiency gains of these steps led to a more than tenfold increase in GDP since 1978. **China's economy has been one of the world's fastest growing economies in recent history, with real growth per annum averaging nearly 10% between 1980 and 2012 and slightly more than 7% between 2013 and 2017.**

The services sector (currently estimated at 52.2% of GDP) and manufacturing sector (estimated at 39.5% of GDP) have increasingly spearheaded the country's economic growth, while **the agriculture sector's contribution has declined from around 30% of GDP in the 1980s to 8.2% in 2017**. However, despite having only 10% of the world arable land, **China remains the largest agricultural economy in the world. The agriculture sector employs 28.3% of the 1.4 billion Chinese.** China is **number one producer of rice, wheat, potatoes, fruits and vegetables, peanuts, tea, millet, barley, cotton, oilseed and soybeans**

2. PROBLEM DEFINITION: Challenges to sustainable agriculture and biodiversity in China

Globally, food systems are now the source of 60% of terrestrial biodiversity loss, 33% of soil degradation and 61% of the depletion of commercial fish stocks. The situation in China is largely consistent with these global statistics.

China's agriculture, particularly pastoral farming and the cultivation of rice, wheat and millet date back to many centuries (Zhang et al., 2014). However, the foundation of the republic in 1949 and **the policy reforms that started in 1978** have been two most phenomenal events in China's agricultural history (Ash, 1988; Ghose, 2014). **These reforms heightened the use of modern technology, high yielding crop varieties, chemical fertilizers, irrigation facilities, and improved farm implements and crop protection measures**. Since then, **there have been dramatic improvements in agricultural production and productivity** and the country has been able to grow most of the food it needs and has become a major exporter of many agricultural products. However, **the drive to increase agri-food production has had a major toll on the environment including, *inter alia* loss of soil fertility, soil erosion, diminishing water resources, and air, soil and water pollution**. Today, **China is top on the list of countries with the highest rate of greenhouse gas emissions in agriculture China**, with use of synthetic fertilizers being one major contributor.

On the other hand**, water scarcity and pollution of water, air and soil coupled with declining soil quality are having a major toll on the agri-food systems in China**. The country has almost 20% of the world's population, and contains only 7% of the world's fresh water. Consequently, China's annual fresh water per capita is less than most other countries.

Pollution further limits the amount of water available for use. It is estimated that **at least one-third of China's lakes and rivers are unfit for human use, and 73% of the watersheds that supply water to China's 30 fast-growing cities face medium to high pollution levels**. While industrial pollution is the most frequently discussed source of pollution, **land use and degradation accounts for about half of the pollution found in China's water**. Fertilizers, pesticides, and livestock waste is carried into lakes, rivers, wetlands and coastal waters. Aquifers are also impacted as rainfall and snowmelt carry pollutants underground.

An assessment by the World Bank (2007), highlights the extent of these impacts. In 2007, t**he economic cost of water scarcity to crop losses in China was estimated at RMB 147 billion, representing 1% share of GDP. The economic impact from water pollution amounted to RMB 6.7 billion** as shown in the Table ES 1 below.

Table ES 1: Impacts of water pollution and Scarcity on agriculture in China (world Bank, 2007)

	Impact	Type of impact	Biophysical Impact	Economic Impact (Billion RMB)	Share of GDP
Water Scarcity	Water Scarcity	Water depletion and pollution	74 Billion m^3	147	1.1%
Water pollution	Crop Loss (from Waste Water Irrigation)	Wheat	4,463 metric tons	6.7	0.05%
		Rice	7,339 metric tons		
		Corn	62,505 metric tons		
		Vegetable	560,771 metric tons		
	Fishery Loss	Number of fishery pollution accidents	1,274	4.3	0.03%
Air Pollution	Crop Loss (from Acid Rain)	Rice	15.4 million metric tons	30	0.22%
		Wheat	16.3 million metric tons		
		Rape	3.6 million metric tons		
		Cotton	0.6 Million metric tons		
		Soya bean	3.6 Million metric tons		
		Vegetable	203 Million metric tons		

Source: World Bank (2007)

In addition, **acidic rain caused by air pollution further exacerbates crop losses, with an economic cost estimated at RMB 30 billion in 2007**.

Challenges to Biodiversity in China

China is one of the twelve countries in the world with richest biodiversity, and the country with richest biodiversity in the Northern Hemisphere. The country's vast land area offers various and complicated types of natural ecosystems such as forests, shrubs, meadows, grasslands, deserts, tundra, wetlands, marine and coastal ecosystems. Its flora and fauna are extremely rich. *Inter alia*, **China's number of higher plant species ranks third in the world and its total number of vertebrate species accounts for 13.7% of the world's total**. China is home to more than 35, 000 species of vascular plants of which about 17,300 are endemic; and nearly 6,500 species of vertebrates of which nearly 667 are endemic. The country **is also a place of origin of important crops such as rice and soybeans beside wild and cultivated fruit trees.**

However, China's biodiversity is increasingly under threat with **agricultural conversion**. **Land use change, driven by agricultural expansion, is creating fragmentation and loss of forests, grasslands, wetlands and other habitats**. Agricultural intensification, agrochemicals, and eutrophication from agriculture runoff are causing pressures on biodiversity both on terrestrial and marine habitats. **The pressures of livestock grazing on forests and grasslands are severe**.

In addition to agricultural impacts, several other factors have been cited as leading causes of China's biodiversity loss including **coastal development and construction of major transportation and hydropower projects, habitat degradation and fragmentation, landscape change, pollution, climate change, invasive alien species and overexploitation of natural resources.**

3. CURRENT SITUATION: China's national level strategies and policies

To address these challenges, the Government of China has taken a number of initiatives. **China has embraced sustainable agriculture and biodiversity conservation,** through a variety of national level strategies and policies, which have evolved over time. In 2013, China adopted **"ecological civilization",** a concept first presented at the 17th National Congress of the Communist Party of China in 2007. **The vision for an ecological civilization is being integrated into economic, political, cultural and social developments, with the aim of establishing spatial layouts, industrial structures, and production and consumption patterns that promote green, cycling and low-carbon development, resource conservation and environmental protection**.

To address **water pollution problems, in 2014, the Chinese Premier, Li Keqiang publicly declared 'war on pollution'**. Since then, the Central Government of China announced major policies on pollution control and remediation. **The Water Pollution Prevention and Control Action Plan ("10-Point Water Plan") was released in April 2015.**

To reduce soil erosion and improve the ecological conditions of degraded ecosystems, China initiated its "Grain for Green" program in 1999 and was implemented across the country in 2002. It is an ambitious, example of payment for ecosystem services program designed to address environmental issues including mitigation and prevention of flooding and soil erosion and poverty alleviations in China.

Promotion of **sustainable agriculture landscapes and natural resource management** are enshrined within the **Thirteenth Five-Year Plan (2016-2020).** It emphasizes**, agriculture modernization, which among other objectives aims to promote water-efficient agriculture and high-quality farmland which can help to ensure food security and improvement in soil, irrigation and drainage facilities**.

To protect and conserve its biodiversity, China has been party to the 'Convention on Biological Diversity (CBD) since 1993 and implemented its first National Biodiversity Conservation Action Plan in 1994. Recently, China updated its National Biodiversity Strategy and Action Plan—NBSAP (2011-2030). In line with NBSAP (2011-2030) and ecological civilization, a series of plans and programmes on biodiversity conservation have been implemented including National Programme for Conservation and Use of Biological Resources (2011-2030); National Programme of Action for Conservation of Aquatic Biological Resources; National Plan for Water Area Zoning of Important Rivers and Lakes (2011-2030); National Plan for Zoning of Marine Areas (2011-2020); National Twelfth Five-year Plan for Implementation of Wetland Conservation Projects (2011-2015); National Plan for Island

Conservation (2011-2020) and National Plan for Conservation and Use of Livestock Genetic Resources. **China has been implementing initiatives such as eco-provinces, eco-cities and eco-counties**. According to the Ministry of Environmental Protection, as of 2014, 15 provinces had begun such initiative; 13 provinces had launched their programmes for eco-provinces; more than 1,000 counties (cities and districts) had begun eco-county initiatives. **As a result, 1,559 eco-towns or communities and 238 eco-villages have been established. To further mainstream biodiversity into local economic and social development, pilot work on building eco-cities with good aquatic ecology has been initiated with the first 46 such cities identified** (Ministry of Environmental Protection, 2014).

4. ACCOUNTING FOR ECOSYSTEM IMPACTS AND DEPENDENCIES

Despite well intended national policies and strategic plans, **challenges to conserve biodiversity and ensure sustainable agroecosystems still remain. Many natural areas and habitats are threatened, for example, about 90% of grasslands are experiencing different degrees of degradation and desertification; 40% of China's major wetlands are facing threats of severe degradation**, especially mudflats and mangroves and according to the 2004 Red List, figures on endangered species is much worse than in previous assessments, with the number of endangered plant species far exceeding earlier estimates.

Within agricultural landscapes, soil erosion and pollution are widespread. A census of arable land in China revealed that over a quarter is of poor quality, half of moderate quality and only one quarter high quality. The main Pressures on soil quality arise from the use of agricultural chemicals, overgrazing and agricultural management practices. **Agricultural pollution is considered to directly threaten aquatic biodiversity and soil health**.

There is increased concern on the potential environmental effects from agricultural landscapes and agri-food systems, broadly. However, there is paucity of studies assessing environmental impacts of agri-food systems across the value chain in china. A **few studies conducted mostly at farm gate points towards significant impacts including land degradation, water and air pollution. Consequently, important ecosystem services including carbon capture, habitat provision as well as provisioning ecosystem services such as food and water are being negatively affected**. An example, demonstrating the extent of these impacts is provided below. The main report provides six such examples.

Case Study ES 1: Agriculture production is among the key drivers to land degradation in China

Land degradation in China is increasingly recognized as an economic, social and environmental problem of great concern. Internationally, the interlocking forces of climate and land use changes are considered as key drivers to land degradation.

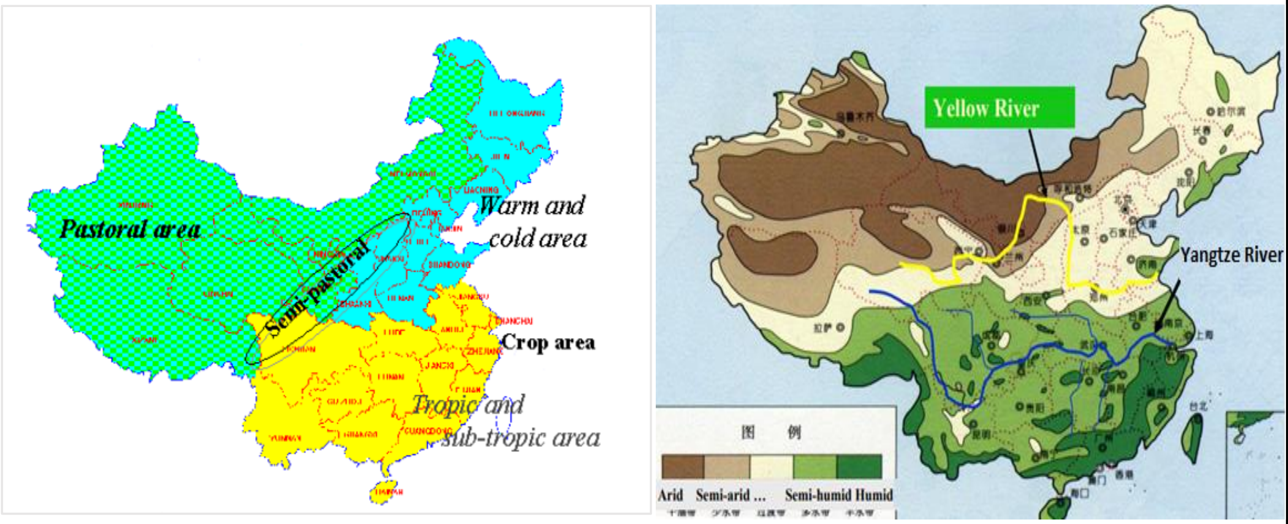
In China, **it is estimated that rapid population growth and urbanization, unreasonable human utilization and influence of natural factors, have caused degradation of 5.392 million km² land, accounting for about 56.2 % of the total national area**. The area of land degradation resulting from soil erosion and water loss, desertification, soil salinization, pasture degradation and soil pollution is

1.8, 0.33, 0.99, 2.0 and 0.27 million km^2, respectively. In relation to agriculture land, **more than 50 % of the total cultivated land has experienced land degradation**. This adds a further strain on agricultural production and is a threat to food security. In addition, **agricultural land degradation directly affects the potential land productivity and because of which more inputs such as fertilizer and irrigation water** would be needed to get the same production and yield level. This leads to **an increase in the production costs and exacerbate pollution of soils and water resources.**

The cost of land degradation in agricultural landscapes in China

To assess the extent of the impact, a study by Deng and Li (2016) assessed the cost of land degradation and the cost of action and inaction against land degradation in China's agro-ecological zones and biomes, based on Land use/land cover change (LULCC) from 2001 to 2009. The Figure ES 1 below shows China's agro-ecological zones (AEZ) and their predominant agricultural use.

Figure ES 1: China's agro-ecological zones



Source: Lalonde and Sukigara (1997)

Source: Xia (2006)

These major agro-ecological zones can be described as follows. (1) The north and north west, generally mountainous and arid to semi-arid, is a predominantly pastoral region. (2) The centre extending to the north east of the country, warm (central) to cold (north east), is a mostly wheat and millet producing region. (3) The tropic and sub-tropic southern region is generally humid to semi-humid and where most crops are grown chiefly, rice.

(1) The cost of land degradation and cost of action and inaction in China across degraded biomes

The cost of land degradation measured in terms of the Total Economic Value (TEV) across agro-ecological zones and degraded biomes as well as the cost of action and inaction are presented in the Table ES 2 below.

Table ES 2: The cost of land degradation due to LUCC for the period of 2001–2009 and cost of action and inaction in China across degraded biomes

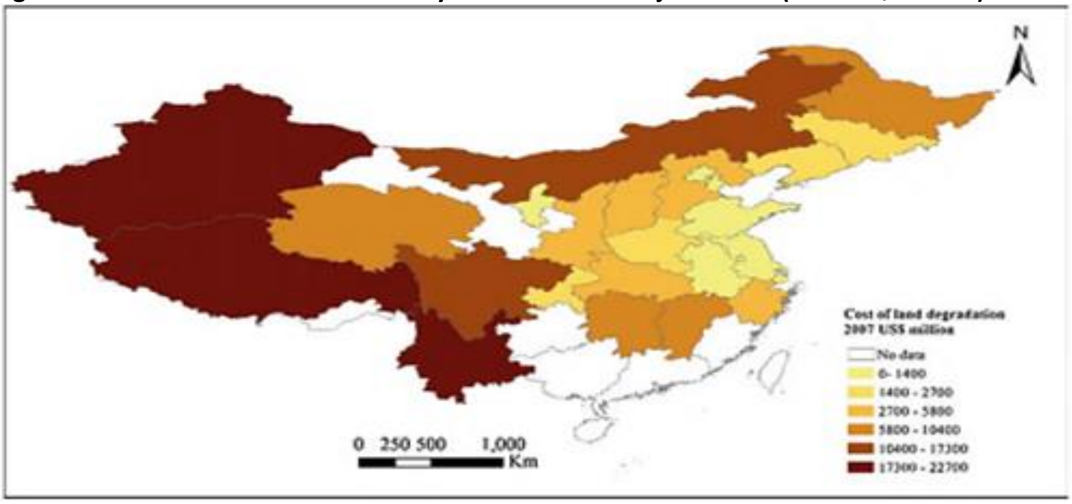
	Agro-ecological Zone			Total
	Arid and semi-arid	Sub-humid	Humid	
	2007 US$ billion			
• TEV	103.37	24.94	67.44	195.75
• Provisioning services	49.91	9.12	25.63	84.66
• Loss of provisioning services as % of TEV	48.28	36.57	38.01	43.25
Cost of restoration of degraded biomes				
• Forest	25.55	21.71	64.59	111.85
• Grassland	68.08	5.64	7.71	81.43
• Shrublands	12.70	4.22	7.49	24.41
• Woodlands	4.33	9.92	23.51	37.76
Cost of				
• Action	110.66	41.50	103.29	255.45
• Inaction	608.57	175.55	423.95	1208.08
MRR of taking action	5.5	4.2	4.1	4.7

Note: TEV is Total Economic Value and MRR is the Marginal rate of return
Source: Deng and Li (2016)

The total cost of land degradation in China due to LUCC for the period between 2001 and 2009 is estimated at about US$ 195.747 billion (in 2007 prices), accounting for 5.4 % of GDP. Annually, the cost of land degradation is estimated at US$ 24.5 billion per year between 2001 and 2009. **The cost of acting against land degradation, to completely rehabilitate the land degraded due to LUCC between 2001 and 2009 in China, was estimated at US$ 255.45 billion over a 30-year period.** On the other hand**, if action is not taken to rehabilitate these degraded lands, China would incur a loss of US $ 1208.08** billion during the same period. The **marginal rate of return (MRR) for investment in restoration of degraded land is 4.7, suggesting very high payoff for taking action**. Restoration of degraded forest accounts for the largest cost. This is followed by restoration of degraded grasslands, especially in the arid and semi-arid areas in north-western China.

The spatial distribution of the total cost of land degradation to ecosystem services is highest in the arid and semi-arid area as shown in the Figure ES 2 below.

Figure ES 2: The economic value of ecosystem service of major biomes (2007 US$ million)



Source: Deng and Li (2016)

The north and north west, generally mountainous and arid to semi-arid, is a predominantly pastoral region. Therefore, land degradation could largely be attributed to overgrazing.

(2) Cost of land degradation on grazing land

Today, livestock production accounts for 40 – 50% of the worldwide agricultural economy and constitutes a vital source of daily protein for people (Herrero et al., 2016). **One of the countries that have experienced notable increases in livestock production is China**. For instance, **the number of cows increased from 52.5 million in 1980 to 84.5 million in 2016; chickens from 0.9 million in 1980 to 5.2 million in 2016; and pigs from 325.7 million in 1980 to 456.8 million in 2016** (FAOSTAT, 2018). Unfortunately, livestock production is currently one of the major contributors to environmental pollution.

The increasing livestock population density and over-exploitation of grazing resources in response to the increasing demand for livestock product**s has resulted in land degradation**. The **cost of land degradation on static grazing lands was US$491 million** (2007 prices) as shown in Table ES 3 below.

Table ES 3: Cost of land degradation on grazing land (2007 US$ million)

Agro-ecological zone	Milk loss cost	Meat loss cost	Total cost	Percent of total cost
	2007 US$ million			
Subtropic-cool/semi-arid	20.59	21.74	42.33	8.6
Subtropic-cool/arid	10.53	11.55	22.08	4.5
Subtropic-cool/humid	0.12	0.04	0.16	0.0
Subtropic-cool/sub-humid	10.01	5.05	15.06	3.1
Temperate/semi-arid	33.26	33.48	66.75	13.6
Temperate/arid	100.56	230.03	330.59	67.3
Temperate/sub-humid	0.43	0.40	0.83	0.2
Tropic-cool/sub-humid	0.91	0.12	1.03	0.2
Tropic-warm/humid	5.61	0.86	6.46	1.3
Tropic-warm/sub-humid	5.09	0.63	5.72	1.2
Total	**187.11**	**303.90**	**491.00**	

Source: Deng and Li (2016)

The loss accounts for only milk and meat production. If other losses were considered, for example, carbon sequestration, the costs could be higher. The temperate arid area in the north-western region accounted for two thirds of the loss. Out of the total loss, meat loss also accounted for 62% of the loss and the remaining 38% accrued to losses in milk production. This can be attributed to the fact that livestock production in temperate rangeland in the north-western China is mostly for meat production.

(3) Cost of land degradation on static cropland

China is among the countries that have the highest rate of fertilizer use in the world, accounting for a third of the global consumption of inorganic nitrogen fertilizer. **The high rate of inorganic fertilizer application is considered the major cause of eutrophication and other environment consequences**. In northern China, concentration of nitrate in groundwater were found to be about 30 times the U.S. EPA recommended levels. At the same time, the adoption rate of organic inputs and integrated soil fertility management (ISFM) is still limited. Although no comprehensive assessment is available, the cost of land degradation to cropland and ecosystems is likely to be substantial.

The cost of cropland degradation for three crops: wheat, maize and rice, was estimated at about US$ 12 billion annually. The **total annual cost of land degradation due to LUCC and using land degrading management practices on cropland and grazing land was US$ 37 billion or about 1 % of China's GDP in 2007**. The costs are illustrated in the Table ES 4 below.

Table ES 4: The annual cost of land degradation cropland and grazing lands

Type of land degradation	Total cost (TEV)	Provisioning services	Cost of land degradation as % of GDP of 2007 US$3494.06 billion	
	2007 US$ billion		Total cost (TEV)	Provisioning services
LUCC	24.46	10.58	0.70	0.30
Livestock	0.49	0.49	0.01	0.01
Cropland	12.13	3.57	0.35	0.10
Total annual cost	**37.09**	**14.64**	**1.06**	**0.42**

Source: Deng and Li (2016)

The estimated cost of land degradation on cropland is conservative, given that the analysis did not include an exhaustive list of all major agricultural crops produced in China**.** Hence for the long-term sustainable development of agricultural economy, it is critical to take sustainable productive land management measures.

5. PROJECT AIMS AND OBJECTIVES: TEEB Implementation in China, "Promoting biodiversity and sustainability in the agriculture and food sector project"

1. To complement the Government of China's initiatives for agriculture sustainability and biodiversity conservation, **the United Nations Environment (UN Environment), with the support of the European Union (EU), launched a four-year project for "Promoting biodiversity and sustainability in the agriculture and food sector in China**.

2. This project is in line with the Cancun Declaration adopted at the 2016 December CBD COP13 in which governments committed to mainstream biodiversity across all sectors. The project would contribute to integrating biodiversity values into national accounting and reporting systems and will encourage sectors that depend or have an impact on biodiversity to adopt integrated approaches for its conservation and sustainable use. In line with the Declaration, the project will also contribute to supporting sustainable production and consumption throughout value chains, the safe and sustainable application of technologies, and the phasing out of harmful incentives and strengthening of positive incentives.

3. **The overall objective of this project is to protect biodiversity and contribute to a more sustainable agriculture and food sector with well-functioning ecosystems**. This will be achieved by:
    - developing and applying instruments to capture the value of ecosystems services across the entire life cycle in the agri-food and the non-food agricultural raw material sectors;
    - identifying intervention options protecting biodiversity and promoting well-functioning ecosystems and by direct engagement with farmers, agri-businesses, government, and civil society (including consumers).

The example above – on the costs of land degradation in agricultural landscapes in China– has not been funded by the UN Environment/EU project, but **demonstrates the often-invisible externalities, impacts and dependencies between the agricultural sector and ecosystems and biodiversity**. This Executive Summary is limited to this one example, but the main report provides six such examples.

The studies presented are more limited in scope that the full TEEBAgriFood assessments that would be conducted under the current UN Environment/EU project. For instance, these analyses do not cover the **entire value chain** 'from farm to fork' (and including final waste management), does not consider all impacts such as **human health**, and do not present a **Theory of Change**, i.e. what can be done to intervene to switch away from the current business-as-usual scenario to an alternative – the sustainable management of agricultural landscapes.

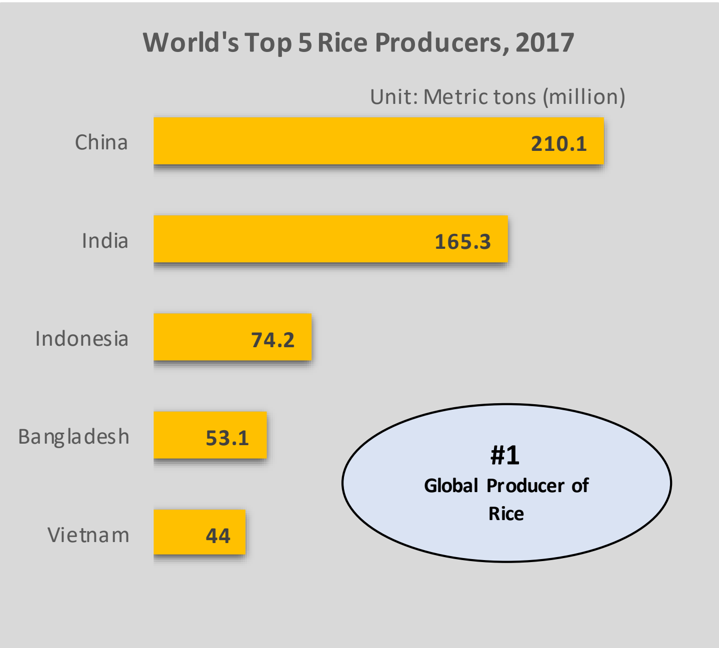
Although 'partial' vis-à-vis the TEEBAgriFood Evaluation Framework, the studies described herein reveal the potential for **complex trade-off** between social- economic and environmental objectives in the China's agri-food systems. Research into this area is still evolving, with an evaluation of possible trade-offs mainly focused at farm level or partial agri-food value chains. More comprehensive analysis of potential social- economic and environmental trade-offs is generally constrained by the complexity of the agri-food value chains and data availability. However, an understanding of these trade-off is crucial for the effective implementation of the China's green agricultural initiatives and biodiversity conservation, and this is the focus of the UN Environment/EU project.

1 Introduction: Snapshot of China's agricultural production

With its GDP (PPP) estimated at USS$ 23.12 trillion in 2017, China is currently the largest economy in the world. China has achieved sustainable economic growth since 1978 when it moved from a closed, centrally planned system to a more market-oriented one. China's reforms started with the phaseout of collectivized agriculture, which was followed by the steady liberalization of prices, fiscal decentralization, increased autonomy for state enterprises, growth of the private sector, stock markets and a modern banking system, and opening to foreign trade and investment. The efficiency gains of these steps led to a more than tenfold increase in GDP since 1978. **China's economy has been one of the world's fastest growing economies in recent history, with real growth per annum averaging nearly 10% between 1980 and 2012 and slightly more than 7% between 2013 and 2017** (CIA, 2017; World Bank, 2018).

China's revolution from a sleeping rural, agricultural giant to manufacturing and service sector superstar propelled rapid infrastructure development, urbanization, rising per capita income and a significant shift in its GDP composition. The services sector (currently estimated at 52.2% of GDP) and manufacturing sector (currently estimated at 39.5% of GDP) have increasingly spearheaded the country's economic growth, while **the agriculture sector's contribution has declined from around 30% of GDP in the 1980s to 8.2% in 2017** (CIA, 2017; World Bank, 2018). However, despite having only 10% of the world arable land (135 million hectares) as of 2015 (National Bureau of Statistics of China, 2016), **China remains the largest agricultural economy in the world. The agriculture sector employs 28.3% of the 1.4 billion Chinese.** The country is **number one producer of rice, wheat, potatoes, fruits and vegetables, peanuts, tea, millet, barley, cotton, oilseed and soybeans**.

China is the world largest producer of rice



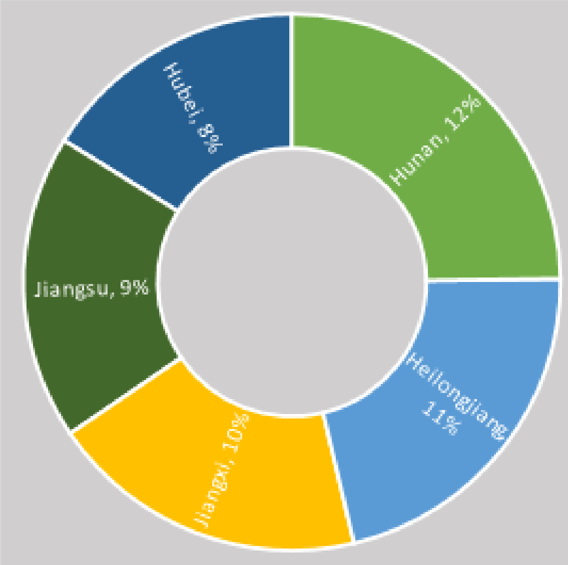
- **China is the world largest producer of rice** which occupies around 30.4 million hectares of land across the country
- **In 2017, China produced 210.1 million metric tons of rice accounting for about 43.4% of global output**
- Most of the rice produced in China is consumed locally. For instance, **as of February 2018, China exported only 1.6 million metric tons, which accounted for 3.4% of the world exports**.

Source: Statista (2018); USDA (2018)

China's high rice output is not necessarily due to land area cultivated but rather its high productivity. As of 2016, rice yield in China stood at 6.9 metric tons per hectare which is world second highest after USA's 8.1 metric tons per hectare (FAOSTAT, 2018).

The top five rice producing provinces in China are Hunan, Heilongjiang, Jiangxi, Jiangsu, and Hubei as shown in Figure 1.

Figure 1: Distribution of regional rice production in China in 2016: The top five



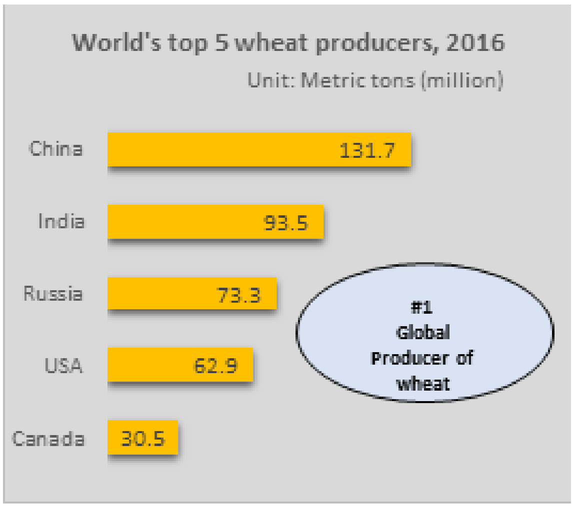
The Longji rice terraces in Guilin, China (Larson-Wang, 2017)

Source: Statista (2018)

Despite being the world largest producer, China is currently a net importer of rice. For instance, by February 2018, China imported 5.5 million metric tons of rice against 1.6 million metric tons exported. Most of the rice that China imports comes from its neighbouring countries. In 2017, China imported over 10% of Thai rice exports, over 30% of Vietnam's and over 50% of Myanmar's (USDA, 2018).

China is the number one world producer of wheat

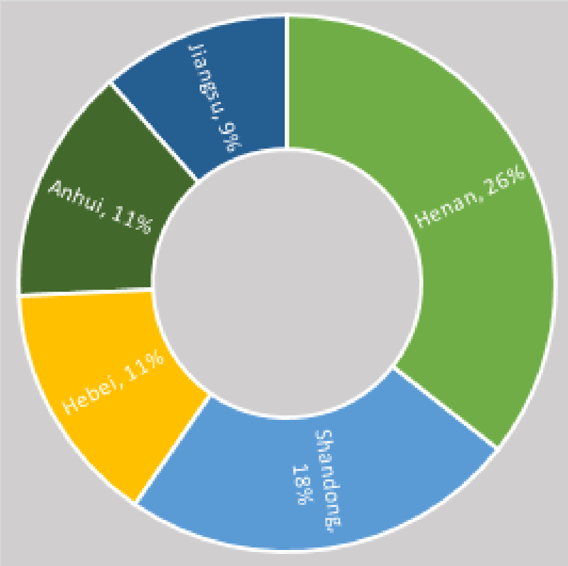
- After rice, **wheat is the second most major cultivated food crop in China**. The country is number one global producer of wheat
- In 2016, China's wheat farms covered a total of 24.3 million hectares, with 131.7 million metric tons produced
- In China, **wheat is predominantly produced in the central part of the country, particularly the Henan province, which accounts for almost one-third of the wheat** harvested.



Source: FAOSTAT (2018)

The top five wheat producing provinces in China are Henan, Shandong, Hebei, Anhui, and Jiangsu as shown in Figure 2.

Figure 2: Distribution of regional wheat production in China in 2016: The top five

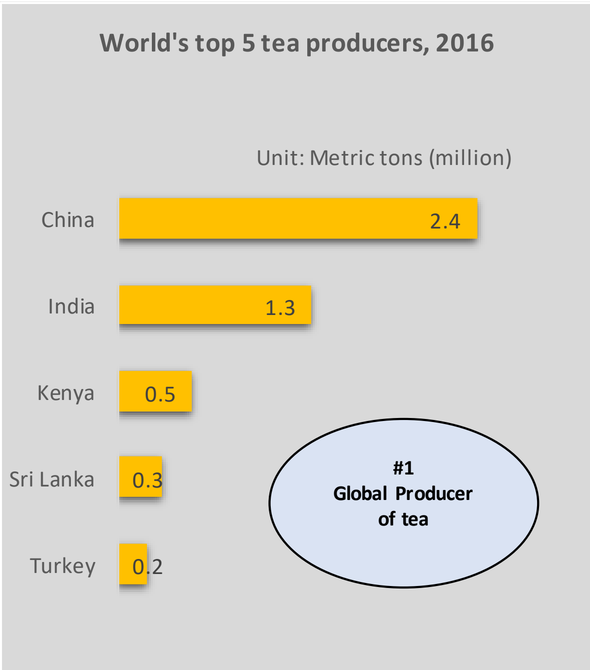


Wheat farm in Xunxian, Henan, China (Zhu, 2016)

Source: Statista (2018)

China is the number one world producer of tea

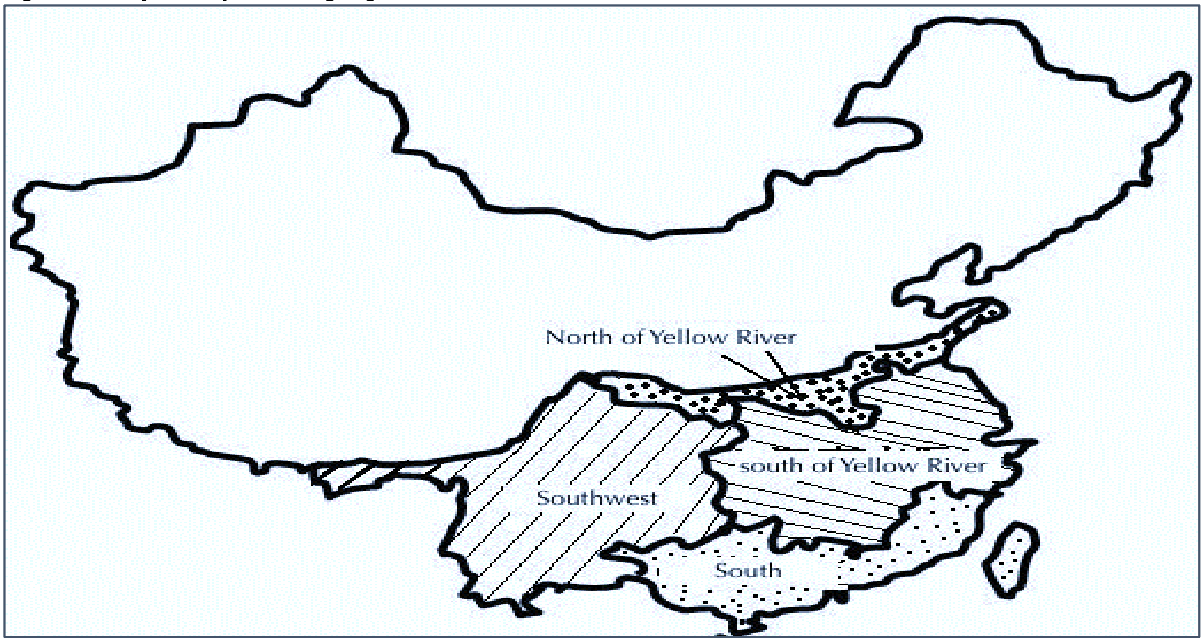
- **China is the world largest producer of tea**
- In 2016, China's tea farms covered a total of 2.2 million hectares, with 2.4 million metric tons produced
- There are several types of tea cultivated but the most popular ones are green tea, black tea, brick tea, oolong tea, white tea and yellow tea
- In 2016, **China exported tea valued at approximately US$1.49 billion, making it the leading exporter of tea worldwide.**



Source: FAOSTAT (2018)

Key tea producing areas in China include (1) **the Southwest region** (Yunnan, Sichuan, Guizhou and the south-eastern parts of Tibet); (2) **the South of China region** (Guangdong, Guangxi, Fujian and Hainan); (3) **the South of Yangtze River region** (Zhejiang, Jiangxi, Hunan and southern parts of Jiangsu, Hubei and Anhui); and (4) **the North of Yangtze River region** (Shandong, Gansu, Shaanxi, Henan and the northern parts of Jiangsu, Anhui and Hubei). These regions are shown in Figure 3.

Figure 3: Major tea producing regions in China



Source: Teasenz (2017)

China is the world third largest producer of cow milk

China is ranked number three worldwide in production of cow milk. The top five world producing countries of cow milk are shown in Table 1.

Table 1: Top five world producers cow milk in 2016

	Country	Cow milk production	
#		Quantity (million MT)	World share (%)
1	USA	96.4	14.6
2	India	77.4	11.7
3	China	37.2	5.6
4	Brazil	33.6	5.1
5	Germany	32.7	4.9

Source: FAOSTAT (2018)

Traditionally, **cow milk is predominantly produced in the north and northwest parts of China, which are mostly mountainous and arid to semi-arid**. For instance, **in 2012, the northeast and inner Mongolia industrial district were the top producers, accounting for the 43% of the total cow milk** in the country. This was followed by the northern industrial district at 31%, the northwest industrial district at 14%, the southern industrial district at 8% and the suburban industrial district at 4 % (Alfons et al., 2014).

China also produces several other crops such as groundnuts, fruits and vegetables, potatoes and sugarcane that put the country on the world map.

#1 Producer of Groundnuts

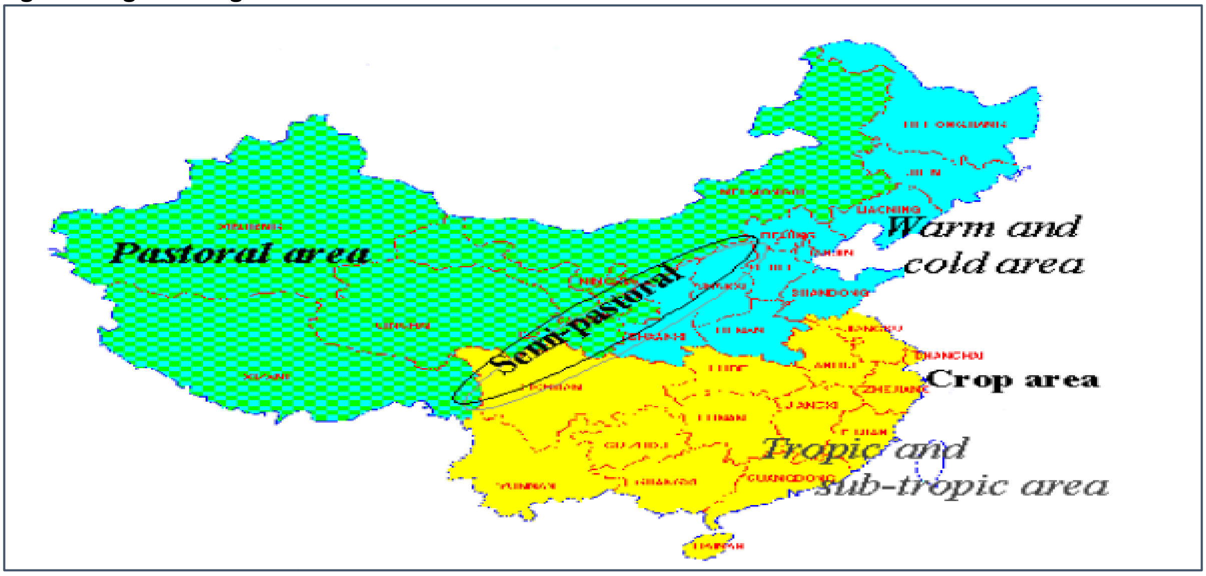
#1 Producer of Fruits & Vegetables

#1 Producer of Potatoes

3rd Largest Producer of Sugarcane

China's robust agriculture sector is divided into three main agro-ecological zones each supporting wide-ranging crops depending on the climatic conditions, topography and soil conditions as shown in Figure 4.

Figure 4: Agro-ecological Zones in China



Source: Lalonde and Sukigara (1997)

These major agro-ecological zones can be described as follows. (1) The north and north west, generally mountainous and arid to semi-arid**, is a predominantly pastoral region**. (2) The centre extending to the north east of the country, warm (central) to cold (north east), **is a mostly wheat and millet producing region**. (3) The tropic and sub-tropic southern region **is where most crops are grown mainly, rice**.

China's robust agriculture sector is supported by its rich endowment of natural resources including biodiversity.

1.1 Snapshot of biodiversity in China

China is one of the twelve countries in the world with richest biodiversity, and the country with richest biodiversity in the Northern Hemisphere. The country's vast land area offers various and complicated types of natural ecosystems such as forests, shrubs, meadows, grasslands, deserts, tundra, wetlands, marine and coastal ecosystems as shown in Table 2. Its flora and fauna are extremely rich. *Inter alia*, **China's number of higher plant species ranks third in the world and its total number of vertebrate species accounts for 13.7% of the world's total**. China is home to more than 35, 000 species of vascular plants of which about 17,300 are endemic; and nearly 6,500 species of vertebrates of which nearly 667 are endemic (Pyne, 2013). The country **is also a place of origin of important crops such as rice and soybeans beside wild and cultivated fruit trees** (Ministry of Environmental Protection, 2014).

Table 2: Distribution of terrestrial ecosystems of China and percentage of areas of all ecosystems in 2010

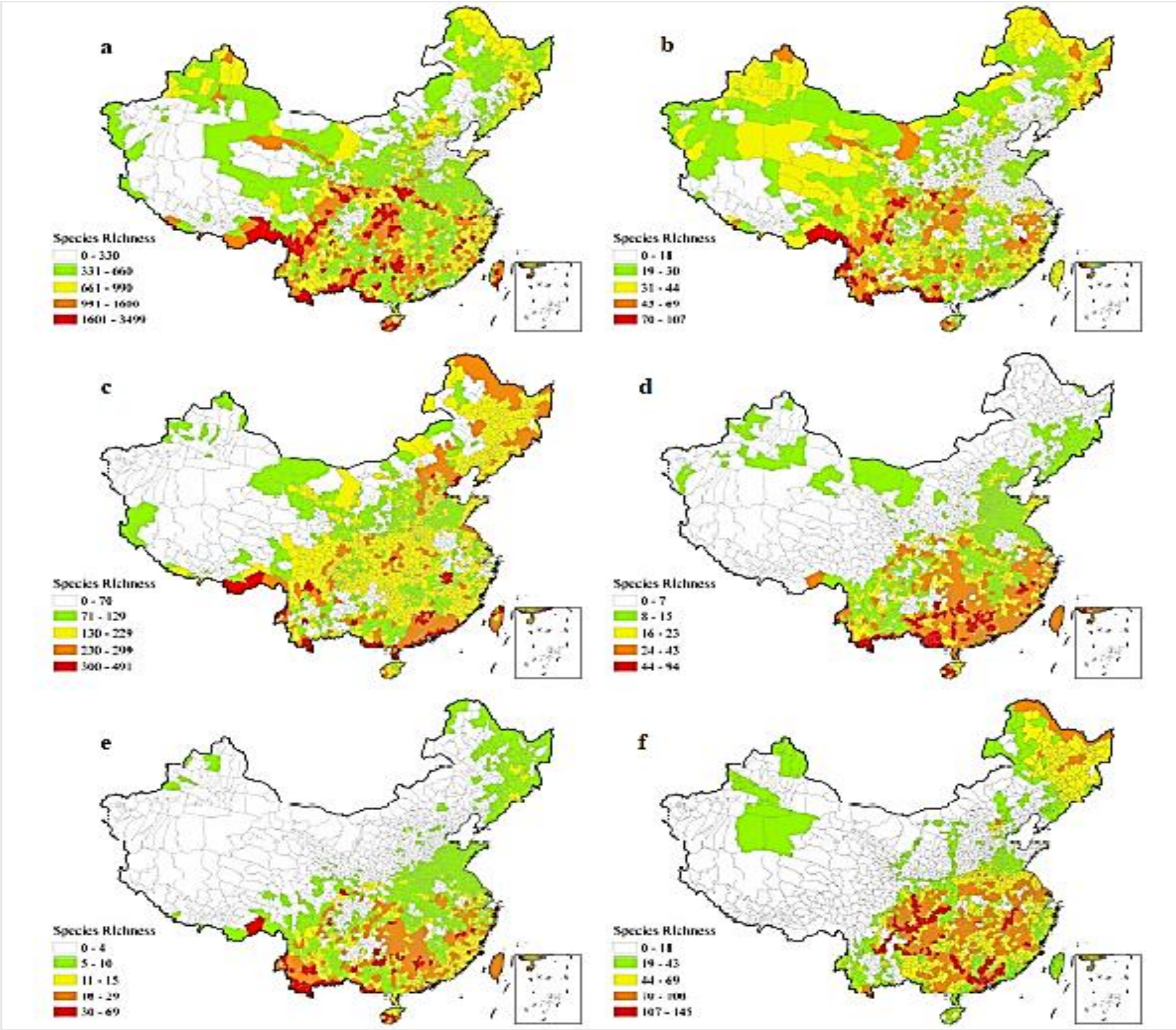
Ecosystem Types	Area ($10^3 km^2$)	Percentage of Areas of All Ecosystems (%)
Grassland ecosystem	284.2	30.0
Forest ecosystem	191.3	20.2
Shrub ecosystem	69.6	7.4
Aquatic and wetland ecosystem	33.8	3.6
Agricultural ecosystem	180.9	19.1
Urban ecosystem	25.4	2.7
Desert ecosystem	126.5	13.4
Others	34.1	3.6

Note: Data above do not include those from Taiwan Province of China

Source: Ministry of Environmental Protection (2014)

China's richness of vascular plants and mammals is characterized by highness in the south and lowness in the north of the country, highness in mountains and lowness in plains as shown in Figure 5.

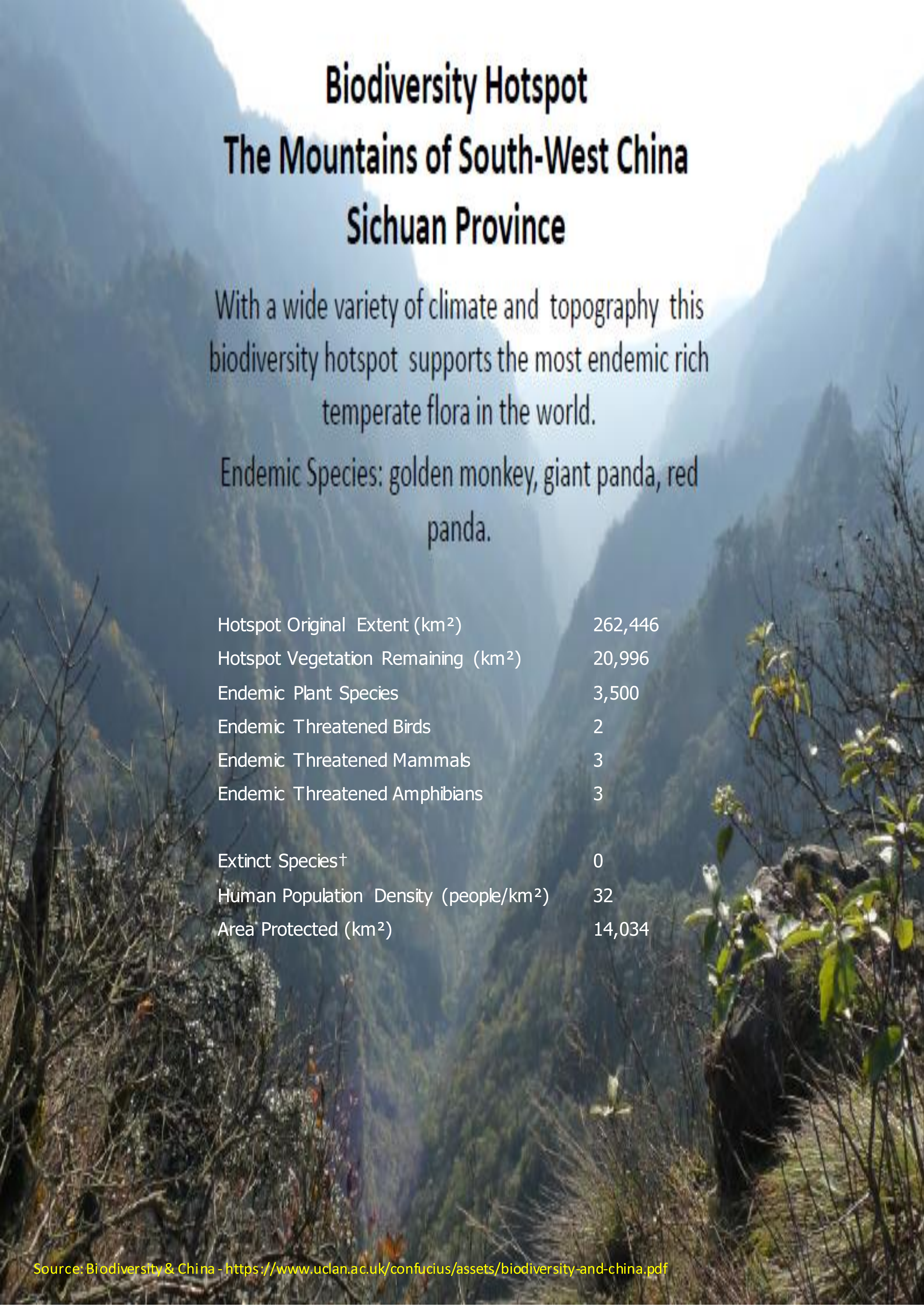
Figure 5: Spatial Distribution of China's Wild Vascular Plant and Vertebrate Species. (a) Vascular plants; (b) mammals; (c) birds; (d) reptiles; (e) amphibians; (f) inland water fishes



Source: Ministry of Environmental Protection (2014)

The key areas rich in vascular plants and mammals are Min Mountain, Qionglai Mountain, Hengduan Mountain, southeastern section of Himalaya Mountain, Qinling Mountain, Daba Mountain, Wuling Mountain, Wuyi Mountain, Xishuangbanna, border areas of southwestern Guangxi, and central and southern parts of Hainan (Ministry of Environmental Protection, 2014).

Of the 34-world biological 'hot spots' (areas of greater biological endemism in the biosphere), **one is in China, the Mountains of Southwest China**.



Biodiversity Hotspot
The Mountains of South-West China
Sichuan Province

With a wide variety of climate and topography this biodiversity hotspot supports the most endemic rich temperate flora in the world.

Endemic Species: golden monkey, giant panda, red panda.

Hotspot Original Extent (km²)	262,446
Hotspot Vegetation Remaining (km²)	20,996
Endemic Plant Species	3,500
Endemic Threatened Birds	2
Endemic Threatened Mammals	3
Endemic Threatened Amphibians	3
Extinct Species†	0
Human Population Density (people/km²)	32
Area Protected (km²)	14,034

Source: Biodiversity & China - https://www.uclan.ac.uk/confucius/assets/biodiversity-and-china.pdf

1.2 Challenges to biodiversity in China

In terms of drivers and pressures, **China experiences threats to biodiversity from agricultural conversion**, a major driver of deforestation in some regions. **Land use change, driven by agricultural expansion, is creating fragmentation and loss of forests, grasslands, wetlands and other habitats**. Agricultural intensification, agrochemicals, and eutrophication from agriculture runoff are causing pressures on biodiversity both on terrestrial and marine habitats. **The pressures of livestock grazing on forests and grasslands are severe** (Ministry of Environmental Protection, 2014).

In addition to agricultural impacts, several other factors have been cited as leading causes of China's biodiversity loss including **coastal development and construction of major transportation and hydropower projects, habitat degradation and fragmentation, landscape change, pollution, climate change, invasive alien species and overexploitation of natural resources** (Ministry of Environmental Protection, 2014).

China has taken important steps towards addressing some of these challenges. In the **last decade, forests area has increased by 23% and the area of forests under environmental protection increased almost 22%**[1]. The health of the grasslands is also being addressed through economic incentives for conservation activity undertaken by herdsmen[2]. Fresh grass output in the project area has increased by 70% and the vegetation structure is stabilizing[3]. **A more comprehensive discussion of biodiversity conservation measures being undertaken is provided in Chapter 2**.

1.3 Challenges to sustainable agriculture in China

Globally, food systems are now the source of 60% of terrestrial biodiversity loss, 33% of soil degradation and 61% of the depletion of commercial fish stocks[4]. The situation in China is largely consistent with these global statistics.

China's agriculture, particularly pastoral farming and the cultivation of rice, wheat and millet date back to many centuries (Zhang et al., 2014). However, the foundation of the republic in 1949 and **the policy reforms that started in 1978** have been two most phenomenal events in China's agricultural history (Ash, 1988; Ghose, 2014). **These reforms heightened the use of modern technology, high yielding crop varieties, chemical fertilizers, irrigation facilities, and improved farm implements and crop protection measures**. Since then, **there have been dramatic improvements in agricultural production and productivity** and the country has been able to grow most of the food it needs and has become a major exporter of many agricultural products (Ghose, 2014). However, **the drive to increase agri-food production has had a major toll on the environment including, *inter alia* loss of soil fertility, soil erosion, diminishing water resources, and air, soil and water pollution**. Today, **China is top on the**

[1] China's Fifth National Report on the Implementation of the Convention on Biological Diversity: China: The Ministry of Environmental Protection of China, 2014. Available at, https://www.cbd.int/reports/nr5/.

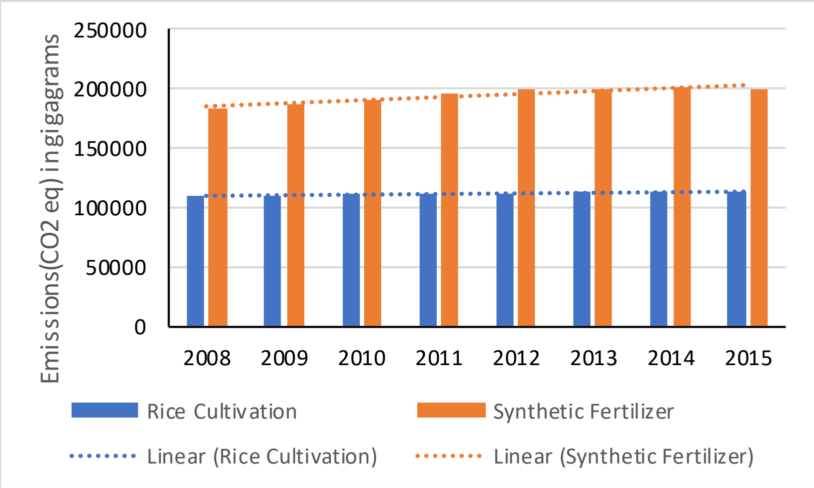
[2] China's Fifth National Report on the Implementation of the Convention on Biological Diversity: China: The Ministry of Environmental Protection of China, 2014. Available at, https://www.cbd.int/reports/nr5/.

[3] China's Fifth National Report on the Implementation of the Convention on Biological Diversity: China: The Ministry of Environmental Protection of China, 2014. Available at, https://www.cbd.int/reports/nr5/.

[4] TEEB. 2015. TEEB for Agriculture & Food: an interim report, United Nations Environment Programme, Geneva, Switzerland.

list of countries with the highest rate of greenhouse gas emissions in agriculture China (FAO, 2015) with use of synthetic fertilizers being one major contributor as shown in Figure 6.

Figure 6: Greenhouse gas emissions in China (2008 – 2015)



- The use of synthetic fertilizers, especially in rice farms is one major cause of high greenhouse gas emissions in China.
- Trend lines suggest an escalating CO2eq emanating from the use of synthetic fertilizers while CO2eq emanating from rice farms appear constant. This may suggest that GHG emission emanating from cultivation of other crops such as wheat may be on the rise.

Source: FAOSTAT (2018)

Today, paddy rice, wheat, maize and soybean are the major crops with high carbon footprint as shown in Table 3.

Table 3: Comparison of carbon footprint between different crops in China

Crop	Area (Mha)	Yield (kg/ha)	CF per unit area (kg CE/ha)	CF per unit of production (kg CE/kg grain)	Overall GHG emissions (Mt CO_2-eq)
Rice	29·87	6716·25	2472·34	0·37	270·81
Wheat	24·26	5550·30	793·68	0·14	70·59
Maize	32·50	6791·10	781·17	0·12	93·09
Soybean	8·52	2220·45	221·91	0·10	6·93

CF: carbon footprint; CE: carbon equivalent; GHG: greenhouse gas
Source: Cheng et al. (2015, p. 425)

Agriculture is driving its own demise

Agriculture is a key driver of environmental degradation. It is directly responsible for approximately 10 – 12% of global greenhouse gas (GHG) emissions and indirectly for roughly another 10%. It is the main driver of land use change and associated biodiversity loss, uses 92% of global fresh water and approximately 20% of primary energy.

Besides causing environmental damage, agriculture is, above all other industries, reliant upon a well-functioning environment. It is vulnerable to temperature extremes, water availability, atmospheric soil and water pollution, pest and disease outbreaks, biodiversity loss, tropospheric ozone, high winds, among others.

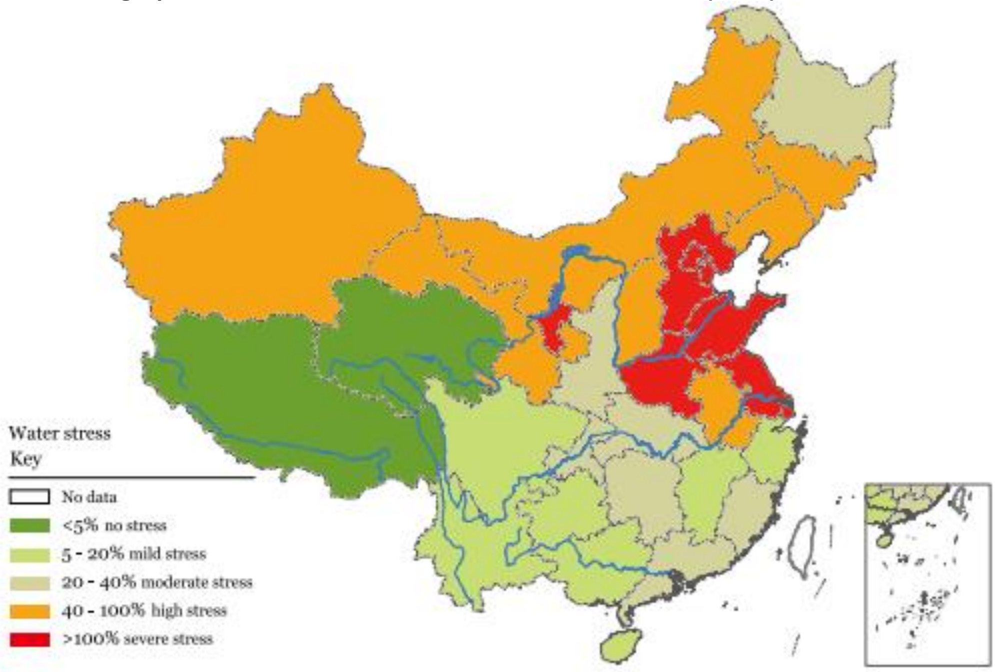
The global agricultural system is thus both a driver and a victim of environmental change.
Source: Gathorne–Hardy (2013, p. 37)

On the other hand, water scarcity and pollution of water, air and soil coupled with declining soil quality are having a major toll on the agri-food systems in China. The situation is compounded further by increased food demand due to population pressure, changing lifestyles, both locally and internationally.

1.3.1 Impact of water scarcity and pollution on agriculture

Water pollution and scarcity is a serious threat to sustainable agriculture in China. The country has almost 20% of the world's population, and contains only 7% of the world's fresh water. Consequently, China's annual fresh water per capita is less than most other countries. For example, provinces experiencing the most severe water resource stress are mostly in the north, as shown in Figure 7. In contrast, provinces along the southeast coast have plentiful water resources, hence low stress (WWF, 2012).

Figure 7: Geographic Distribution of China's water resource stress (2009)



Source: WWF (2012)

Besides water scarcity, pollution further limits the amount of water available for use. It is estimated that **at least one-third of China's lakes and rivers are unfit for human use, and 73% of the watersheds that supply water to China's 30 fast-growing cities face medium to high pollution levels**. While industrial pollution is the most frequently discussed source of pollution, **land use and degradation accounts for about half of the pollution found in China's water**. Fertilizers, pesticides, and livestock waste is carried into lakes, rivers, wetlands and coastal waters. Aquifers are also impacted as rainfall and snowmelt carry pollutants underground (WWF, 2012).

An assessment by the World Bank (2007), highlights the extent of these impacts. According to their assessment, t**he economic cost of pollution to crop losses in China was estimated at RMB 6.7 billion, and the economic impact from water scarcity at RMB 147 billion** as shown in Table 4.

Table 4: Impacts of water pollution and Scarcity on agriculture in China (world Bank, 2007)

	Impact	Type of impact	Biophysical Impact	Economic Impact (Billion RMB)	Share of GDP
Water Scarcity	Water Scarcity	Water depletion and pollution	74 Billion m^3	147	1.1%
Water pollution	Crop Loss (from Waste Water Irrigation)	Wheat	4463 metric tons	6.7	0.05%
		Rice	7339 metric tons		
		Corn	62,505 metric tons		
		Vegetable	560,771 metric tons		
	Fishery Loss	Number of fishery pollution accidents	1274	4.3	0.03%
Air Pollution	Crop Loss (from Acid Rain)	Rice	15.4 million metric tons	30	0.22%
		Wheat	16.3 million metric tons		
		Rape	3.6 million metric tons		
		Cotton	0.6 Million metric tons		
		Soya bean	3.6 Million metric tons		
		Vegetable	203 Million metric tons		

Source: World Bank (2007)

In addition, **acidic rain caused by air pollution further exacerbates crop losses**, with an economic cost estimated at RMB 30 billion in 2007.

To address **water pollution problems, in 2014, the Chinese Premier, Li Keqiang publicly declared 'war on pollution'**. Since then, the Central Government of China announced major policies on pollution control and remediation. **The Water Pollution Prevention and Control Action Plan ("10-Point Water Plan") was released in April 2015** (Central People's Government of the People's Republic of China, 2015).

To reduce soil erosion and improve the ecological conditions of degraded ecosystems, China initiated its "Grain for Green" program in 1999 and was implemented across the country in 2002. It is an ambitious, example of payment for ecosystem services program designed to address environmental issues including mitigation and prevention of flooding and soil erosion and poverty alleviations in China (Zhou et al., 2012). By 2010, in **regions where the "Grain for Green" program was implemented such as Ansai County in Shanxi Province, newly forested land increased by 21.4%** but at the expense of cropland and shrub–grassland, which decreased by 46.3% and 18.8%, respectively, from 1995 to 2010 (Zhou et al., 2012).

1.3.2 Impact of climate change on agriculture

Over the past century, China has experienced some noticeable climate change. According to the China Meteorological Administration (CMA), the average temperature of the earth's surface in China has risen by 1.1 degrees Celsius between 1908 and 2007 (Chih-Yin Lai, 2011). The last Century has also witnessed an increasingly uneven distribution of precipitation between the south with abundant water and the drier north, as well as some extreme climate events, for example, the great flood in 1998 and the 2010–2011 drought (Chen et al., 2016).

The heavy flooding in the summer of 1998, along the banks of Yangtze river and its tributaries caused extensive damage on China's economy. **According to governmental estimates, 223 million people**

(one fifth of China's population were affected), 3,004 people died and 15 million were made homeless and 15 million farmers lost their crops. The floods caused severe damage to critical facilities such as health clinics, schools, water supply, and other infrastructure including roads, bridges and irrigation systems as well as industrial facilities. By the end of August, **direct economic damage was estimated at over US$ 20 billion.** The cause of the disaster was excessive rainfall, which, according to the Chinese meteorologists was ascribed to the worldwide El Niño phenomenon followed by La Niña. Deforestation was also cited as a contributing factor (UNDAC, 1998).

Currently, studies on the impact of climate change on agriculture show mixed results. **Evidence points towards, the assertion that climate change will not have a significant impact on China's agriculture**. For example, a study by Xiong et al. (2007), simulated the average yield changes per hectare of three main grain crops (rice, wheat, and maize) and found no adverse climate change impacts. Other studies carried out at farm level show mixed results, mainly due to difference in the data used. For example, Liu et al. (2004) found that global warming had a positive impact on China's agriculture, while a study by Wang et al. (2009) found the impact of climate change to be negative.

More recently, a study by Chen et al. (2016) estimated the relationship between corn and soybean yields and weather at national level using corn and soybean average yields from 2005-2009. They included temperature, precipitation, and radiation as weather variables. After controlling for other factors that could affect county-average crop yields, such as input use and farmers' contemporaneous climate adaptation behaviours, **they found that global warming has caused an economic loss of about US$ 820 million to China's corn and soybean sectors in the past decade. Their study further projected a decline in corn and soybean yields by 3–12% and 7–19%, respectively, by 2100.**

Land is another constraint to agricultural production. China has around 22% of the world's population but only 10% of the world arable land (National Bureau of Statistics of China, 2016). Thus, **land scarcity, pollution and water scarcity coupled with climate change and population pressure are among the major challenges to the sustainability of the agri-food systems**.

To address these challenges, the Government of China has taken a number of initiatives. Regarding serious environmental problems, **the Government of China is committed to reduce the total amount of major pollutants**. For example, in the past decade, the overall annual average concentration of major pollutants has been decreasing. **According to the Ministry of Environmental Protection, as of 2014, the intensity of emission of pollutants per unit of GDP had decreased by over 55%.** Since 2004, the density of CO_2 emission per unit of GDP has decreased by 15.2% (Ministry of Environmental Protection, 2014).

China has also expressed interest in combating global climate change. At the 2015 United Nations Climate Change Conference, **China submitted an Intended Nationally Determined Contribution (INDC) and made a commitment to reduce greenhouse gas emissions per unit of gross domestic product by 60-65% from 2005 levels by 2030**[5].

[5] http://climateactiontracker.org/countries/china/2015.html

In addition, **China has embraced sustainable agriculture and biodiversity conservation,** through a variety of national level strategies and policies, which have evolved over time. In 2013, China adopted **"ecological civilization",** a concept first presented at the 17th National Congress of the Communist Party of China in 2007. **The vision for an ecological civilization is being integrated into economic, political, cultural and social developments,** with the aim of establishing spatial layouts, industrial structures, and production and consumption patterns that promote green, cycling and low-carbon development, resource conservation and environmental protection (Ministry of Environmental Protection, 2014).

Promotion of **sustainable agriculture landscapes and natural resource management** are enshrined within the **Thirteenth Five-Year Plan (2016-2020).** It emphasizes**, agriculture modernization, which among other objectives aims to promote water-efficient agriculture and high-quality farmland which can help to ensure food security and improvement in soil, irrigation and drainage facilities** (Central Committee of the Comunist Party of China, 2016).

To protect and conserve its biodiversity, China has been party to the 'Convention on Biological Diversity (CBD) since 1993 and implemented its first National Biodiversity Conservation Action Plan in 1994. Recently, China updated its NBSAP for the next two decades (2011-2030). In line with these commitments and ecological civilization, a series of plans and programmes on biodiversity conservation have been implemented including National Programme for Conservation and Use of Biological Resources (2011-2030); National Programme of Action for Conservation of Aquatic Biological Resources; National Plan for Water Area Zoning of Important Rivers and Lakes (2011-2030); National Plan for Zoning of Marine Areas (2011-2020); National Twelfth Five-year Plan for Implementation of Wetland Conservation Projects (2011-2015); National Plan for Island Conservation (2011-2020) and National Plan for Conservation and Use of Livestock Genetic Resources. **China has been implementing initiatives such as eco-provinces, eco-cities and eco-counties**. According to the Ministry of Environmental Protection, as of 2014, 15 provinces had begun such initiative; 13 provinces had launched their programmes for eco-provinces; more than 1,000 counties (cities and districts) had begun eco-county initiatives. **As a result, 1,559 eco-towns or communities and 238 eco-villages have been established. To further mainstream biodiversity into local economic and social development, pilot work on building eco-cities with good aquatic ecology has been initiated with the first 46 such cities identified** (Ministry of Environmental Protection, 2014).

1.4 TEEB Implementation in China: Promoting biodiversity and sustainability in the agriculture and food sector project

1. To complement the Government of China's initiatives for agriculture sustainability and biodiversity conservation, **the United Nations Environment (UN Environment), with the support of the European Union (European Commission), launched a four-year project for "Promoting biodiversity and sustainability in the agriculture and food sector in China**.

2. This project is in line with the Cancun Declaration[6] adopted at the 2016 December CBD COP13 in which governments commit to mainstream biodiversity across all sectors. The project would contribute to integrating biodiversity values into national accounting and reporting systems and

[6] http://www.cbd.int/cop/cop-13/hls/Cancun%20Declaration-EN.pdf

will encourage sectors that depend or have an impact on biodiversity to adopt integrated approaches for its conservation and sustainable use. In addition, and in line with the Declaration, the project will contribute to supporting sustainable production and consumption throughout value chains, the safe and sustainable application of technologies, and the phasing out of harmful incentives and strengthening of positive incentives.

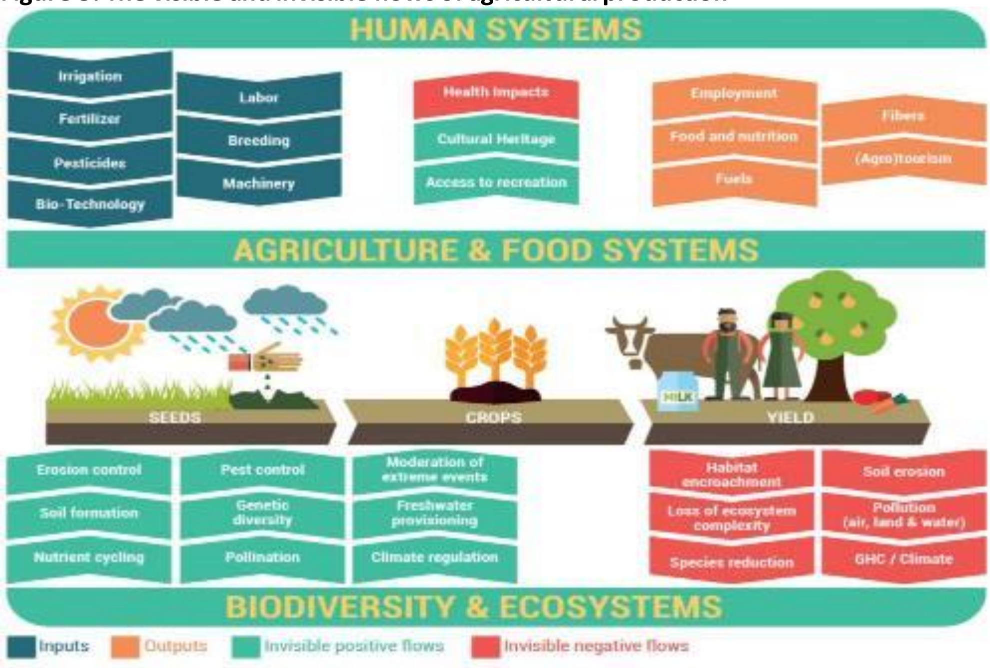
3. **The overall objective of this project is to protect biodiversity and contribute to a more sustainable agriculture and food sector with well-functioning ecosystems**. This will be achieved by:
    - developing and applying instruments to capture the value of ecosystems services across the entire life cycle in the agri-food and the non-food agricultural raw material sectors;
    - identifying intervention options protecting biodiversity and promoting well-functioning ecosystems and by direct engagement with farmers, agri-businesses, government, and civil society (including consumers).

4. The TEEBAgriFood Framework[7] will be used to assess the sectors for the EU Partner countries in scope. The focus in this action is capturing the value of ecosystems services, protecting biodiversity and promoting well-functioning ecosystems of the framework. The action aims to be comprehensive, from farm to fork (i.e. across the entire value chain). The Framework allows decision-makers (regulators, agri-business and farmers) to see explicitly any trade-offs that arise through the application of different measures, as compared with Business-As-Usual (BAU).

5. The rationale for the development of the TEEBAgriFood Evaluation Framework, is to provide a comprehensive and universal framework that captures all the positive and negative impacts and externalities across the entire agri-food value chain. It is a frame of reference that can enable us to answer the question “what we should value, and why?” It can be used to evaluate a policy question, a business question or an accounting question[8]. The TEEBAgriFood schematic (Figure 8) below provides a visual illustration of some of the impacts and externalities that might be omitted were we not to apply a holistic and comprehensive evaluation framework.

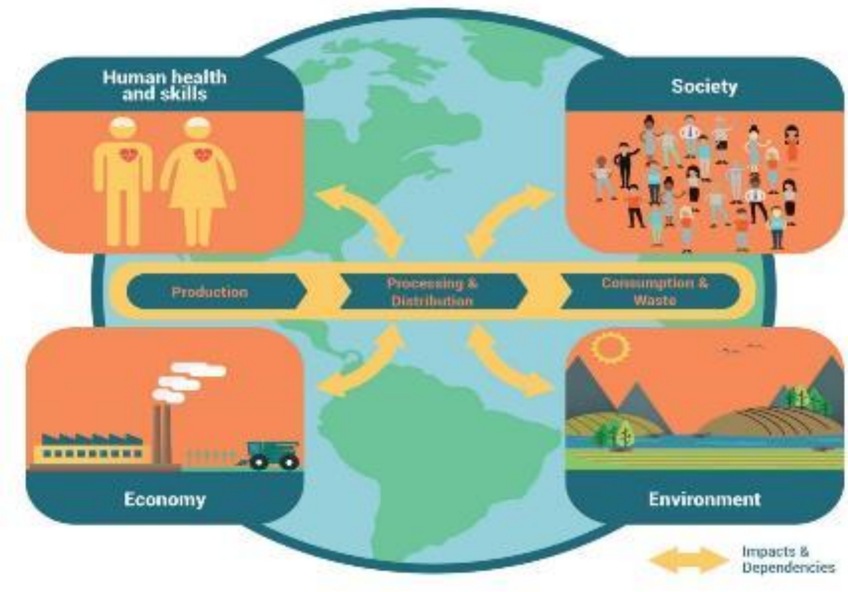
[7] The current published version of the Evaluation Framework can be found here: http://www.teebweb.org/agriculture-and-food/#framework. The Framework that is to be published in the upcoming TEEBAgriFood ‘Foundations’ report is an evolution of this previous version but retains the same core components. The ‘Foundations’ report is due to be published in Q1 2018 and thus the Framework will be finalized before the current EC Partnership Instrument project is contracted.
[8] For more details, see Chapter 3 in the TEEBAgriFood Interim Report: http://www.teebweb.org/publication/teebagfood-interim-report/

Figure 8: The visible and invisible flows of agricultural production



The schematic in Figure 6 above refers to the impacts and dependencies that occur within the farm-gate, but the Evaluation Framework looks at inter-linkages across the value chain, and trade-offs across capital stocks in the eco-agri-food systems complex. This is illustrated in the schematic below (Figure 9).

Figure 9: The eco-agri-food systems complex



6. The project builds on the momentum of the international TEEB initiative[9], TEEB country studies[10], TEEB for Agriculture and Food[11] and on national interest.

[9] http://www.teebweb.org/
[10] http://www.teebweb.org/areas-of-work/country-studies-home/
[11] http://www.teebweb.org/agriculture-and-food/

7. It also builds on the on-going UN Environment/TEEB initiatives in China.
    - In 2013, China adopted **"ecological civilization",** a concept first presented at the 17th National Congress of the Communist Party of China in 2007. To achieve eco-civilization, the Government of China plans to improve property rights and use control systems of natural capital, draw 'red lines' or 'no-go' zones for ecological protection, implement instruments like payment for ecosystem services and ecological compensation, and reform environmental management systems.
    - In this context, the Ministry of Environmental Protection (MEP) and the Chinese Academy of Sciences (CAS) jointly **developed the TEEB China project, to value ecosystem services and biodiversity, and mainstream these values into governmental policy decision processes at various scale**[12].
    - Currently, the **TEEB China National Action Plan**, led by MEP and CAS, has been approved by an expert review. It is planned to be implemented over the course of three years, with six components, and 22 detailed actions. These components are: systemizing current TEEB theory and methodologies; developing TEEB China methodology; selecting pilot sites and case studies; raising awareness and training for TEEB; international collaboration and communication; and promoting the mainstreaming of TEEB into policy.
8. TEEB will work closely with:
    - The Natural Capital Protocol, and links will be made to ensure representation from those firms which have already committed to Protocol on the project meetings.
    - The Partnership Instrument project "Natural Capital Accounting and Valuation of Ecosystem Services" (AAP 2015) involving UNDESA, UNEP-TEEB and the Secretariat of the Convention on Biological Diversity (sCBD) which aims to apply macro accounting in five countries including China.
    - BIOFIN[13] is a global partnership developed to improve biodiversity management through sound financing and economic thinking. BIOFIN works directly with Finance and Environmental ministries in 30 countries helping them to understand how to use finance solutions to maintain ecosystems and the services they provide, and China is part of this partnership.
    - UN-REDD Safeguards[14] were developed to promote benefits and protect against potential risks during the implementation of REDD+ actions. Five Aichi Targets including Targets 5 and 7 are relevant for REDD+ Safeguard.

Beyond these specific country links, there are complementarities between this project and initiatives providing guidance and opportunities in this space including FAO-OECD Guidelines on Responsible Supply Chains; the BioTrade initiative managed by UNCTAD[15]; the Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services (IPBES)[16]; ESMERALDA[17] (Enhancing Ecosystem Services Mapping For Policy And Decision Making); FAO assessment/Platform on mainstreaming biodiversity in agricultural sectors[18] and DG Research and Innovation initiatives such as FOOD 2030[19].

[12] http://www.craes.cn/c/cn/news/2015-01/27/news_4511.html
[13] Can be found: http://www.biodiversityfinance.net. Assessed Nov 2017
[14] Can be found: http://www.unredd.net/knowledge/redd-plus-technical-issues/safeguards.html. Assessed Nov 2017
[15] www.biotrade.org
[16] http://www.ipbes.net/
[17] http://www.esmeralda-project.eu/
[18] http://www.fao.org/biodiversity/en/
[19] http://ec.europa.eu/research/conferences/2016/food2030/index.cfm

2 Overview of national policies in agriculture and biodiversity

China's economy is built on the concept of planning, carried out via "Five-Year Plans", which are primarily centralized and integrated national economic programs. Thus, missions and schemes are formulated in line with the plans. **The first plan was from 1953 to 1957 and the most recent one, the thirteenth plan, is from 2016 to 2020**.

2.1 The Thirteenth Five-Year Plan

Developed by the CPC Central Committee and the State Council, **the goal of the Thirteenth Five-Year Plan (2016-2020) is** to "**finish building a moderately prosperous society in all respects by the time the CPC celebrates its centenary in 2021[20].**" Regarding sustainable management of natural resources and agriculture modernization, the following are envisaged.

Sustainable management of natural resources
(1) Promote society-wide energy and water conservation efforts;
(2) Promote economical and intensive use of land designated for construction purposes;
(3) Improve forest cover;
(4) Establish demonstration zones for green mining and the green mining industry
(5) Preserve biodiversity, marine environment and wildlife.

Agriculture modernization
(1) Develop high-quality farmland;
(2) Modernize the seed industry;
(3) Encourage water-efficient agriculture;
(4) Promote agriculture mechanization;
(5) Promote intelligent agriculture;
(6) Promote agricultural product quality and safety;
(7) Cultivate new types of agribusiness;
(8) Foster integrated development of the primary, secondary, and tertiary industries in rural areas.

A number of agricultural modernization projects are envisaged as outlined below, which among other objectives include the promotion of water-efficient agriculture and high-quality farmland in order to ensure food security and improve soil, irrigation and drainage facilities (Central Committee of the Comunist Party of China, 2016).

[20] The other goal of the thirteenth five-year plan is to turn the People's Republic of China into a modern socialist country that is prosperous, strong, democratic, culturally advanced, and harmonious by the time it celebrates its centenary in 2049.

Agricultural Modernization Projects in China

1. **High-quality farmland development**

- With the focus on major grain crop production areas, give top priority to the development of high-quality farmland which can help to ensure food security; implement farmland projects to improve soil and build irrigation and drainage facilities, roads for farm equipment, farmland shelterbelt networks, and electricity transmission and distribution facilities; and ensure the development of 53 million hectares of high quality farmland, while aiming for the completion of 67 million hectares;
- Assess, grade, and monitor the quality of arable land.

2. The modern seed industry

- Develop a national system for the collection, storage, and research of germplasm resources;
- Strengthen research and development of key technologies for crop heterosis exploitation, molecular design breeding, cell and chromosome engineering, high- efficiency seed production, and fine and deep processing of seeds;
- Strengthen capacity for seed quality inspection;
- Establish national seed production centers in Hainan, Gansu, Sichuan, and other provinces, and 100 regional superior seed production centers.

3.Water-efficient agriculture

- Spread the application of water-efficient irrigation and promote water-efficient projects, crop breeds, agronomy, and management;
- Accelerate the implementation of regional scaled high-efficiency water-saving irrigation projects, using water-conserving methods to increase crop production in the northeast, raise irrigation efficiency in the northwest, address groundwater overdraft in the north, and reduce waste water discharge in the south;
- Increase the area of cropland making use of high-efficiency water-conserving irrigation by 6.7 million hectares, thereby raising the irrigation water utilization coefficient to 0.55 or above.

4. Agricultural mechanization

- Make breakthroughs in mechanizing the transplanting of rice seedlings, the sowing and harvesting of canola seeds, and the harvesting of cotton and sugarcane;
- Promote the use of high-horsepower and high-performance agricultural machinery and light, durable, and lower-power small and medium plowing, planting, and harvesting machines and crop protection machines;
- Develop 500 counties able to demonstrate mechanization of the entire agricultural process;
- See that mechanization of the plowing, planting, and harvesting of major farm crops reaches approximately 70%.

5. **Intelligent agriculture**

- Introduce “Internet +” modern agriculture, facilitate the adoption of the Internet of Things in field planting, livestock and poultry production, and fishery operations, and support e-commerce, logistics, commercial, trade, and financial enterprises in participating in the development of e-commerce platforms for farmers, rural areas, and agriculture;
- Establish monitoring, analysis, and early-warning systems based on agricultural information.

6**. Agricultural product quality and safety**

- Make a serious push to reduce pesticide and chemical fertilizer use in the production of agricultural products;
- Develop pollution-free agricultural products, green foodstuffs, organic agricultural products, and agricultural products using geographical indications;
- Strengthen epidemic disease and pest monitoring and early-warning systems and green prevention and control, establish an information traceability system for oversight over the quality and safety of agricultural products, and achieve interconnection and information sharing between all types of platforms for products tracing information;
- Ensure that livestock antibiotics are properly used and that the indexes for pesticide and livestock medicine residues are basically in line with Codex Alimentarius standards.

7. **Cultivation of new types of agribusiness**

- Develop demonstration family farms, demonstration agricultural cooperatives, agricultural industrialization demonstration centers, and demonstration service organizations;
- Implement the modern agricultural talent development plan;
- Cultivate leaders of new types of agribusiness, and train young managers capable of operating modern farms, people with practical skills for rural areas, and a new type of professional farmer.

8**. Integrated development of the primary, secondary, and tertiary industries in rural areas**

- Implement the “100 counties, 1,000 townships, 10,000 villages” pilot demonstration project to promote the integrated development of the primary, secondary, and tertiary industries in rural areas;
- Create a number of integrated development models and forms of business that can be replicated elsewhere;
- Develop a number of rural enterprises that can take the lead in integrating the development of the primary, secondary and tertiary industries;
- Cultivate a number of areas that can lead the way in integrated development.

Source: Central Committee of the Comunist Party of China (2016)

In addition to the Five-Year Plan, at the beginning of every year, the CPC Central Committee and the State Council release a policy document on agriculture. This document, commonly known as **the No. 1 Document**, conventionally focuses on agricultural and rural issues and is regarded as a key policy document that outlines goals for the upcoming year. **In the 2018 No. 1 Document, China intends to (1) ensure national food security through intensive and value-added productivity growth and development of Chinese state-owned global commodity market actors; (2) reform domestic support programs for grains; (3) build ties with Belt and Road trading partners; (4) foster land reform initiatives; and (5) expand access to rural financial products and facilitate capital allocation** (GAIN Report, 2018).

2.2 The evolution of agricultural policy

China's evolution of agricultural policies dates back to 1978 when the country moved from a closed, centrally planned system to a more market-oriented one. *Inter alia*, China's reforms started with the phaseout of collectivized agriculture, which was followed by the steady liberalization of prices, fiscal decentralization, growth of the private sector, and opening to foreign trade and investment. By 1988, China's agricultural reforms had gone through two phases as shown in Table 5 below.

Table 5: Preliminary stages of strategic and policy issues of China's agriculture

	Central strategy	Main policy issues	Principal agricultural policy documents
First stage of rural reform (1978-1984)	Restructuring of rural economy through institutional change, based on decentralization of farming operations	• Evolution of household responsibility systems • Reform of the commune system • Diversification of the agricultural and rural economies and the emergence of specialized households • Price, tax and quota adjustment	• Regulations on the work in rural people's communes (1979) • Decision of the Central Committee of the Chinese Communist Party on some questions concerning the acceleration of agricultural development (1 July 1979) • Directive of the Central Committee of the CCP regarding several issues concerning the further strengthening and perfection of the production responsibility systems in agriculture (Document 75, (27 September 1980) • Various questions concerning current rural economic policy (Document 1) (1 January 1983) • Circular of the Central Committee of the CCP on rural work during 1984 (Document 1) (1 January 1984)
Second stage of rural reform (1985-1988)	Restructuring of rural economy through an extension of market and price regulations	• Reform of the state monopoly purchase and marketing system • The roles of prices and markets • Investment in agriculture • Diversification and employment • Conservation and utilization of land	• The policies of the Central Committee of the CCP and State Council for the further invigoration of the rural economy policy (Document 1) (1 January 1985) • Plans of the Central Committee of the CCP and State Council for rural work during 1986 (Document 1) (1 January 1986) • State Council circular on perfecting the contractual system of grain purchases (October 1986)

Source: Ash (1988, pp. 530-531)

The Agricultural Support Policy

In the 1980s and 1990s, China launched a **demonstration program** to improve livestock in pastoral regions, **lean hog production bases in 400 counties, a vegetable basket system** to expand food supplies to cities, and a **straw for ruminants campaign** to feed cattle and sheep on crop residues (Gale, 2013). However, major policy changes in the agriculture sector began in the early 2000 when Chinese officials implemented **a broad program of agricultural support** that included tax reductions, direct subsidies, price supports, policy loans, expenditure on infrastructure, and intergovernmental transfers as summarised in Table 6.

Table 6: Timeline of China's agricultural support programs

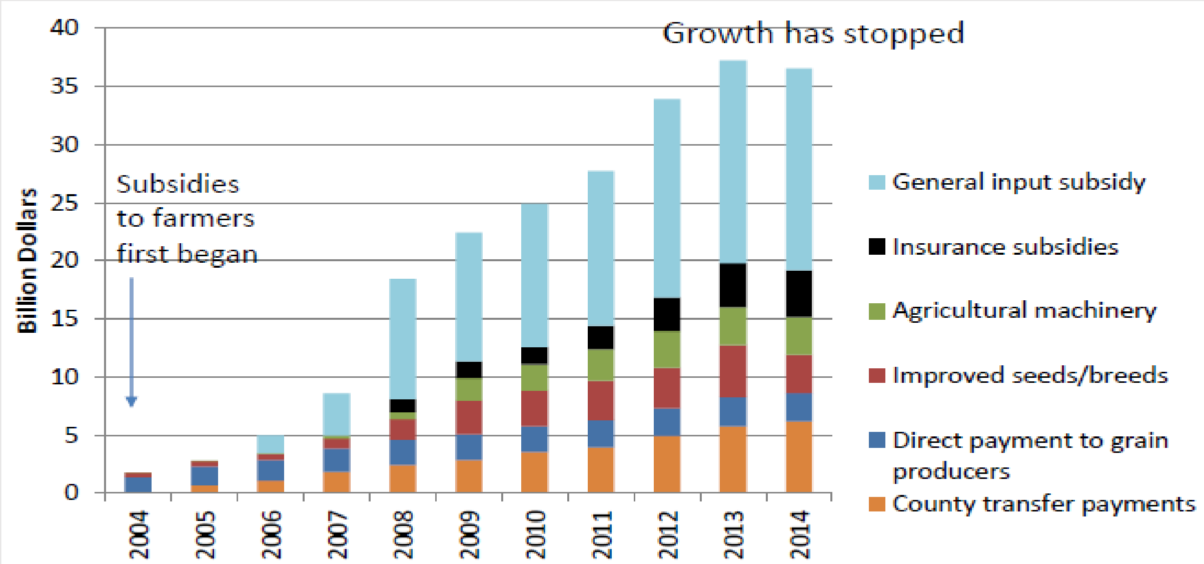
Year	Policy measure	Commodities
2000	• Pilot reforms of rural taxes and fees	
2002-03	• Soybean seed subsidy and pilot grain subsidy programs in several regions	Soybeans, rice, wheat, corn
2004-06	• Direct payment to grain producers • General-input subsidy • Improved seed subsidy • Machinery subsidy • Transfer payments to grain counties • Reform of grain marketing system • Eliminated agricultural tax, specialty crop and animal slaughter taxes • Rice and wheat price supports	Rice, wheat, corn, soybeans
2007	• Package of pork industry subsidies introduced and expanded • Seed subsidy for cotton and rapeseed • Transfer payments to oilseed and pork counties	Pork, cotton, rapeseed
2008	• General-input subsidy linked to input prices • Support prices for corn, soybeans, rapeseed, pork, sugarcane • Strategy of raising price supports annually adopted	Soybeans, rice, wheat, corn, rapeseed, pork, sugarcane
2009	• Hog price intervention program	Pork
2011	• Cotton price support • Grassland protection program	Cotton, cattle, sheep
2015	• Price support amended to "direct payment" if price falls below the target price	Cotton, Soybeans
2016	• Price support abolished	Cotton

Source: Gale (2013, p. 4)

China's agricultural policy reforms, particularly the agricultural support programs, have been pursued with three key goals. **(1) to modernize agriculture through adoption of modern inputs, increasing investment, expanding scale of farms, and promoting marketing links, (2) to minimize/remove rural-urban income inequality and (3) to maintain food security and self-reliance** (Anderson, 2017; Gale, 2013).

China's production subsidies, which included direct payments, improved seeds, and agricultural machinery purchases, increased to over US$35 billion by 2014 as shown in Figure 10.

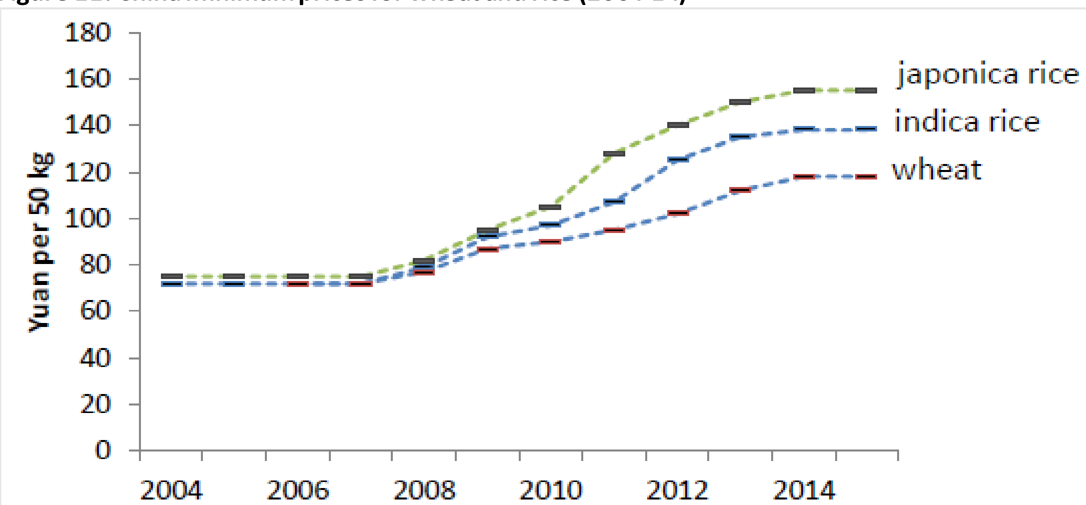
Figure 10: China's major agricultural subsidies: expenditures 2004-14



Source: Gale (2016, p. 6)

Under the agricultural support policy, China introduced a minimum purchase price and temporary reserve programs to encourage production of targeted crops in key producing regions as well as guarantee producers a minimum price for their commodities. Whenever the grain market price fell below the minimum, farmers could sell their commodities to state enterprises. **The minimum purchase price was first applied to rice in 2004 and wheat in 2006. In 2008, a temporary reserve program was introduced for corn, rapeseed, soybeans, pork, and sugarcane; and in 2011 for cotton** (Hejazi & Marchant, 2017). The agricultural support policy led to two key issues. Firstly, although the minimum purchase prices were initially set below world market prices, they increased annually. For instance, between 2008 and 2013, minimum purchase price for rice increased by 92% while that of wheat increased by 57% as shown in Figure 11.

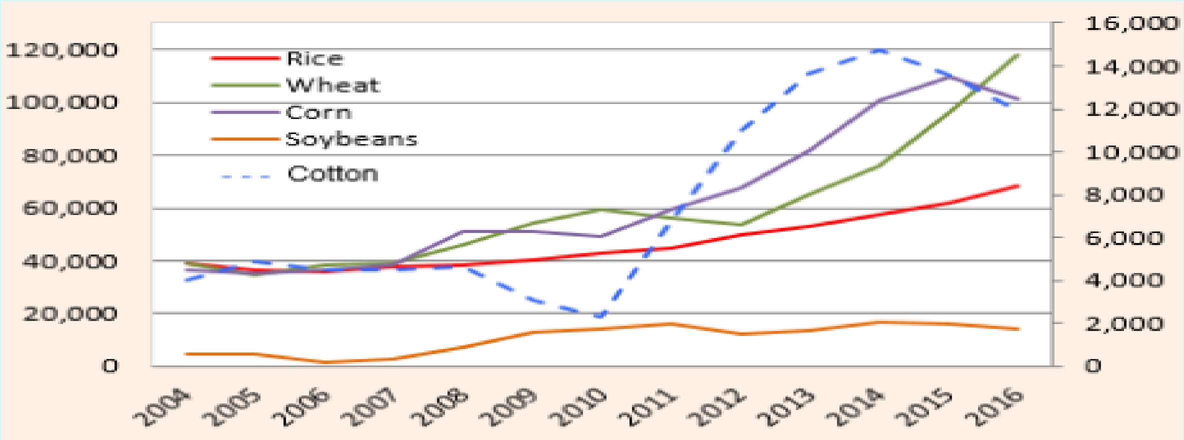
Figure 11: China minimum prices for wheat and rice (2004-14)



Source: Gale (2016, p. 8)

With such high minimum purchase price, China found itself a net importer of some major commodities such as rice. Secondly, partly due to the first issue as well as the increase in production owing to the support programs, the country ended up with a stockpile of major crops such as corn, cotton, and wheat as shown in Figure 12.

Figure 12: China's Stockpiles of major agricultural commodities (2004-16)



Source: Figure generated from USDA-FAS, Market and Trade Data, Production, Supply and Distribution (PSD), 2016.
Note: (left axis: 1,000 MT and cotton is shown on the right axis 1000 bales (480 lb.))

Source: Hejazi and Marchant (2017, p. 2)

Essentially, down the road, **the agricultural support policy did not only distort China's agricultural markets but it also created a financial burden and new challenges for the government**. To get out of this quagmire, changes had to be made. As such, **in 2015, China removed its price support program for major agricultural commodities, except for rice and wheat**; and **in 2016, the price support for corn was abolished**. Earlier, in 2015, China amended the price support for cotton and soybeans in which farmers would receive a direct payment from the government should the market price fall below the target price; but the government would not purchase and store the two commodities (Hejazi & Marchant, 2017).

2.3 Policies on biodiversity conservation in China

To protect and conserve its biodiversity, China has been party to the 'Convention on Biological Diversity (CBD), since 1993 and implemented its first National Biodiversity Conservation Action Plan in 1994. More recently, China updated its NBSAP for the next two decades (2011-2030). The new strategy contains 3 goals, 8 strategic tasks, 10 priority domains, 30 priority actions, 35 priority areas for conservation and 39 priority projects for implementation[21].

2.3.1 National Biodiversity Strategy and Action Plan (NBSAP) 2011-2030

To strengthen its biodiversity conservation efforts, on 17 September 2010, the Government of China updated and launched the National Biodiversity Strategy and Action Plan (NBSAP) 2011-2030. It is being implemented in tandem with relevant national plans developed with a view to building an

[21] https://www.cbd.int/countries/profile/default.shtml?country=cn

ecological civilization, some of which are highlighted in the previous section. The NBSAP 2011-2030 provide a comprehensive set of national targets for biodiversity conservation as shown in Table 7.

Table 7: China's national targets for biodiversity conservation

1. Short-term goal: by 2015, the trend of biodiversity decline in key regions will be effectively contained, specifically including:
• Biodiversity status surveys and assessments will be undertaken in 8 to 10 priority areas for biodiversity conservation, and these areas will be effectively monitored; • In-situ conservation will be strengthened and terrestrial protected areas will be maintained at 15% or so of the country's land area, protecting 90% of national key protected species and typical ecosystem types; • Ex-situ conservation will be undertaken on a scientific basis, providing effective protection of 80% of endangered species in areas where in-situ conservation is not adequate or whose wild population is very small; • Forest coverage rate will be increased to 21.66% and forest reserves will be increased by 600 million m3 over those in 2010; • A system of monitoring, assessment and early warning of biodiversity, as well as those systems for access to and benefit-sharing of genetic resources and import and export of biological resources will be preliminarily established; • Main pollutants will be reduced considerably, with COD and SO2 emission to be reduced by 8%, NOx and ammonia nitrogen by 10% compared with those in 2010; • Major progress will be made in building a resource-efficient and environmentally friendly society.
2. Mid-term goal: by 2020, biodiversity decline and loss will be basically controlled, specifically including:
• Biodiversity status surveys and assessments will be completed in all priority areas for biodiversity conservation, with all these areas to be effectively monitored; • National forest holdings will exceed 2.23 million km^2, an increase of about 223,000 km^2 over that of 2010, and national forest reserves will exceed 15 billion m^3, an increase of 1.2 billion m^3 over that of 2010; • The cumulative areas of control of degraded, salinized and desertified grasslands will exceed 1.65 • million km^2, and grassland degradation trend will be contained, with obvious improvements in grassland ecology and balance between herds and grass supply in natural grasslands achieved; • The environmental and ecological degradation of the near-shore marine areas will be fundamentally reversed, and the decline of marine biodiversity will be basically contained; • The aquatic ecosystems will be gradually restored and the depletion of fishery resources and the increase in the number of endangered species will be basically contained; • A network of nature reserves with reasonable layouts and sound functions will be established, with functions of national-level nature reserves stabilized and main protection targets effectively protected; • The biodiversity monitoring, assessment and early warning system as well as the system for management of import and export of biological resources and access to genetic resources and benefit-sharing from their use will be improved, and the documentation of associated traditional knowledge and intellectual property rights protection system will be further improved; • The percentage of total investments from all sources into research and development will be increased to over 2.5% of GDP, with the rate of contributions from science and technology exceeding 60%; • Energy consumption and CO_2 emissions per unit of GDP will be reduced significantly, and the total amount of main pollutants will be obviously reduced.
3. Long-term Goal: By 2030, biodiversity will be effectively protected.

Source: Ministry of Environmental Protection (2014, p. 3)

China conducted an assessment on its progress to achieving NBSAP targets as shown in Table 8.

Table 8: Assessment of China's progress in achieving the NBSAP targets

Actions	Assessment	Actions	Assessment
1 Develop policies that promote biodiversity conservation and sustainable use	considerable progress	16 Strengthen establishment of conservation farms for livestock genetic resources	considerable progress
2 Improve legal system for biodiversity conservation and sustainable use	considerable progress	17 Develop an *ex-situ* conservation system on a scientific basis	considerable progress
3 Establish and improve biodiversity conservation and management bodies and improve cross-sectoral coordination mechanisms	considerable progress	18 Develop and improve system of storing genetic resources	considerable progress
4 Mainstream biodiversity into regional and sectoral planning processes and plans	considerable progress	19 Strengthen reintroduction of artificially bred species and recovery of wild species	some progress
5 Ensure sustainable use of biodiversity	some progress	20 Strengthen research, development and innovation in use of genetic resources	considerable progress
6 Reduce impacts of environmental pollution on biodiversity	considerable progress	21 Establish a system and mechanism for access to and benefit-sharing of genetic resources and associated TK	some progress
7 Undertake baseline surveys of status of biological resources and ecosystems	some progress	22 Establish a system of inspection and examination of import and export of genetic resources	some progress
8 Survey and inventory genetic resources and associated traditional knowledge	considerable progress	23 Upgrade capacities of early warning and monitoring of and emergency response to alien species invasion	some progress
9 Undertake monitoring and early warning of biodiversity	some progress	24 Establish and improve system of biosafety assessment, monitoring and detection of GMOs	considerable progress
10 Enhance and coordinate information systems for genetic resources	significant progress	25 Develop an action plan for addressing climate change impacts on biodiversity	some progress
11 Undertake comprehensive biodiversity assessments	considerable progress	26 Assess impacts of biofuels on biodiversity	some progress
12 Improve and coordinate implementation of protected areas planning across the country	considerable progress	27 Strengthen scientific research in the field of biodiversity	some progress
13 Strengthen protection in priority areas for biodiversity conservation	some progress	28 Strengthen personnel training in the field of biodiversity conservation	some progress
14 Strengthen standardized management of PAs and their management effectiveness	considerable progress	29 Establish mechanisms for broad public participation	some progress
15 Strengthen biodiversity conservation in areas outside PAs	considerable progress	30 Promote establishment of partnerships for biodiversity conservation	some progress

Note: fully achieved; significant progress; considerable progress; some progress; no progress

Source: Ministry of Environmental Protection (2014, p. 9)

From Table 8, it appears that by 2014, China had made significant progress on its road to achieving the NBSAP targets. However, some challenges remain. For instance, there was little progress regarding ensuring sustainable use of biodiversity, undertaking baseline surveys of status of biological resources and ecosystems, undertaking monitoring and early warning of biodiversity, strengthening protection in priority areas for biodiversity conservation and strengthening reintroduction of artificially bred species and recovery of wild species. The same is applicable to targets number 21 all the way to 30, except 24. However, China has done extremely well regarding enhancing and coordinating information systems for genetic resources.

2.3.2 National Biodiversity Action Plan (NBAP) and related Aichi Targets

At the tenth meeting of the COP, countries were called upon to implement the Strategic Plan for Biodiversity 2011-2020 as the overarching biodiversity framework. On 29 September 2011, the Ministerial Declaration of the Group of 77 and China reiterated the importance of translating the Strategic Plan's Aichi Targets into national biodiversity strategies and action plans (NBSAPs).

Accordingly, China's National Biodiversity Action Plan has been developed in line with Aichi Targets as outlined in Table 9.

Table 9: China's National Biodiversity Action Plan

Reference	Target	Related Strategic Goals/Aichi Targets
National Target	Practical efforts will be made in environmental education and communication, popularizing environmental knowledge and increasing public environmental awareness.	1
National Target	By 2030, biodiversity conservation will become voluntary action of the public.	1
National Target	Resource consumption, environmental damage and ecological benefits will be incorporated into the system of assessing social and economic development, and a system of goals and targets, as well as related assessment methods and reward/penalty mechanisms that meet requirements for building an ecological civilization will be established.	2
National Target	Establishment of mechanisms for ecological compensation and increasing fiscal transfers to key ecological function zones will be accelerated; and studies will be undertaken on the establishment of national specialized funds for ecological compensation and the system of reserves for sustainable development of resource-efficient enterprises will be promoted.	3
National Target	By 2015, considerable progress will be made in building a resource-efficient and environmentally friendly society.	4
National Target	Efforts will be made to promote spatial layouts, industrial structure, production and consumption patterns and lifestyles that promote green, recycling and low-carbon development, natural resources conservation and the environmental protection.	4
National Target	By 2015, forest coverage rate will be increased to 21.66% and forest reserves will be increased by 600 million m3 over that in 2010.	5
National Target	By 2020, grassland degradation trend will be basically contained and grassland ecological environment will be obviously improved.	5
National Target	By 2020, the environmental and ecological worsening trends in coastal and near-shore areas will be fundamentally reversed and marine biodiversity decline trend will be basically contained.	5
National Target	By 2020, aquatic environment and ecology will be gradually restored and decline of fishery resources and increase in endangered species will be basically contained.	5
National Target	By 2020, aquatic environment and ecology will be gradually restored and decline of fishery resources and increase in endangered species will be basically contained.	6
National Target	By 2020, the environmental and ecological worsening trends in coastal and near-shore areas will be fundamentally reversed and marine biodiversity decline trend will be basically contained.	6
National Target	By 2020, national forest holdings will exceed 2.33 million km2, an increase 223,000 km2 over that of 2010; and national forest reserves will be increased to 15 billion m3, an increase of about 1.2 billion m3 over that of 2010.	7
National Target	By 2020, husbandry production pattern will be changed and grassland sustainability will be effectively enhanced.	7
National Target	By 2020, fishing capacities and outputs will be generally consistent with carrying capacities of fishery resources.	7

National Target	By 2015, the total amount of emission of main pollutants will be significantly reduced, with COD and SO2 reduced by 8%, and ammonia and Nox reduced by 10% compared with the levels of 2010.	8
National Target	By 2020, energy consumption and CO2 emission per unit of GDP will be reduced significantly, with the total amount of main pollutants considerably reduced.	8
National Target	By 2020, forest pest disaster rate will be controlled at 4%.	9
National Target	By 2020, energy consumption and CO2 emission per unit of GDP will be reduced significantly.	10
National Target	By 2020, a system of nature reserves with reasonable layouts and comprehensive functions will be established, with functions of national-level nature reserves stable, and main targets of protection effectively protected.	10
National Target	By 2015, the total area of terrestrial nature reserves will be maintained at 15% or so of the country's land area, protecting 90% of national key protected species and typical ecosystem types.	11
National Target	The percentage of the area of marine protected areas out of the marine areas under China's jurisdiction will be increased from 1.1% in 2010 to 3% in 2015.	11
National Target	By 2020, the total area of marine protected areas will exceed 5% of the marine areas under China's jurisdiction, with the area of coastal marine protected areas exceeding 11%.	11
National Target	By 2020, a system of nature reserves with reasonable layouts and comprehensive functions will be established, with functions of national-level nature reserves stable, and main targets of protection effectively protected.	11
National Target	By 2015, more than 80% of endangered species whose wild populations are very small and for which in-situ conservation capacities are inadequate will be effectively protected.	12
National Target	By 2020, functions of national-level nature reserves will be maintained stable, and main targets of protection effectively protected.	12
National Target	By 2020, the majority of rare and endangered species and populations will be restored and reproduced, relieving the situation of species endangerment.	12
National Target	By 2020, biodiversity loss will be basically contained, and a system of nature reserves with reasonable layouts and comprehensive functions will be established, with main targets of protection effectively protected.	13
National Target	National List of Protection of Livestock Genetic Resources will be revised so as to accord key protection to rare and endangered livestock genetic resources in the list and ensure that protected varieties will not be lost and their economic values will not be decreased.	13
National Target	By 2020, the stability of ecosystems will be strengthened, and the human environment will be considerably improved.	14
National Target	By 2020, grass-herd balance will be achieved in natural grasslands, grassland habitats will be obviously restored and grassland productivity will be significantly enhanced.	14
National Target	By 2020, the environmental degradation of the coastal and near-shore marine areas will be reversed, and decline of marine biodiversity will be basically contained.	14
National Target	By 2020, forest areas will be increased by 52,000 km2 over that in 2010, and forest reserves net increased by 1.1 billion km2 over that in 2010, and forest carbon sinks by 416 million tons.	15

National Target	By 2020, the total areas of control of degraded grasslands will exceed 1.65 million km2, with grassland habitats obviously restored and grassland productivity significantly enhanced.	15
National Target	By 2020, the aquatic environment and ecology will be gradually restored.	15
National Target	By 2020, the system of access to genetic resources and benefit-sharing from their use will be improved.	16
National Target	Updated NBSAP has been promulgated.	17
National Target	By 2020, documentation of relevant traditional knowledge within China and the intellectual rights protection system will be further improved.	18
National Target	By 2020, the percentage of investment in research and development activities will exceed 2.5% of national GDP, with contributions from science and technology to GDP reaching 60%, and the number of annual patent grants to the Chinese individuals and groups and of citations of academic papers by international journals ranking top five in the world.	19
National Target	Environmental education will be undertaken to popularize environmental knowledge and increase public environmental awareness.	19
National Target	Channels of investment will be broadened and investments from local and central governments will be increased and financing from the banking sector, international donors and the civil society will be attracted to biodiversity conservation, with diverse financing mechanisms established.	20

Source: https://www.cbd.int/nbsap/targets/default.shtml

Table 10 provides an assessment of China's progress towards achieving the Strategic Plan for Biodiversity (2011-2020) Aichi targets.

Table 10: Assessment of China's progress in achieving the 2020 Aichi targets

Targets	Indicators	Trends
1. Awareness of biodiversity increased	Items related to China's biodiversity searched through Google or Baidu	✓
3. Incentive measures	Ecological compensation and investments into key ecological projects	✓
4. Sustainable production and consumption	Reductions in pollutants	✓
	Indicators for sustainable consumption	•••
5. Habitat degradation and loss reduced	Forest areas and growing stock	✓
	Wetland ecosystem areas	✓
	Grassland ecosystem areas	✗
	Fresh grass output from natural grasslands	✓
	Areas of desert ecosystems reduced	✓
	Ecological degradation	•••
6. Sustainable fishery	Marine trophic index	✓
	Red List Index of fishes	✗
	Fishery impacts on biodiversity	•••
7. Sustainable agriculture, aqua-culturing and forestry	Forest growing stock	✓
	Grass output from natural grasslands	✓
	Agricultural impacts on biodiversity	•••
8.Environmental pollution controlled	Reductions in pollutants	✓
9. Invasive alien species controlled	Number of new IAS found every two decades*	✓

Targets	Indicators	Trends
10. Pressures on coral reefs and other vulnerable ecosystems reduced	Reductions in pollutants	✓
	Forest growing stock	✓
	Reductions in areas affected by soil erosion	✓
	Biodiversity of coral reefs	•••
	Climate change impacts on biodiversity	•••
11. Strengthen system of protected areas and management effectiveness	Number and area of protected areas	✓
	Ecological representativeness and management effectiveness of protected areas	•••
12. Endangered species protected	Red List Index	✗
13. Genetic resources protected	Number of local varieties	✗
14. Important ecosystem services restored and ensured	Net income per capita of rural households and reduction in number of people living in poverty	✓
	Forest growing stock	✓
	Reductions in areas affected by soil erosion	✓
	Reductions in desertified areas	✓
15. Ecosystem resilience and carbon sequestration increased	Forest growing stock	✓
	Reductions in areas affected by soil erosion	✓
	Reductions in desertified areas	✓
17. NBSAP Implementation	Implementation of policies and programmes	✓
19. Scientific & technological achievements developed and applied	Academic papers on biodiversity	✓
	Items related to China's biodiversity searched through Google or Baidu	✓
20. Significant increase in investments	Investments into key ecological projects	✓

Note: ✓ Increasing; ✗ Decreasing; ••• No adequate data; * IAS negative impacts on biodiversity increasing

Source: Ministry of Environmental Protection (2014, p. 11)

Table 10 suggests that although by 2014, China had made good progress on its 2020 Aichi targets, some challenges remained. Major challenges were faced primarily in the areas concerning (a) reduction of habitat degradation and loss, (b) sustainable fishery, (c) protection of endangered species and (d) protection of genetic species. In some cases, data was not available.

Overall, there has been important milestone towards biodiversity conservation worth highlighting including the establishment of a system of in-situ conservation such as nature reserves, forest parks, community-based conservation areas, protected sites of wild plants, wetland parks, desert parks, geological parks, special marine protected areas and germplasm conservation farms.

By the end of 2013, China had established 2,697 nature reserves, covering an area of about 1.463 million km² which accounts for about 14.8% of China's land area; 2,855 forest parks, covering an area of 174,000 km²; 225 national-level scenic spots and 737 province-level scenic spots, covering an area of about 194,000 km² or 2% of China's land area; over 50,000 community-based conservation areas have been established, covering over 15,000 km^2; 179 national-level protected sites of agricultural wild plants; 468 wetland parks; 45 national-level special marine protected areas (marine parks) have been established, covering a total area of 66,800 km^2; and 368 national-level conservation areas for aquatic germplasm resources have been set up, covering an area of over 152,000 km^2.

To conserve and restore habitats, a number of key ecological projects are being implemented, including natural forests protection, returning cultivated lands to forests, returning grazing land to grassland, forest belt construction in north, northeast and northwest China as well as in the Yangtse River and coastal areas, control of sandstorms affecting Tianjin and Beijing, comprehensive control of desertification in rocky areas, wetland protection and restoration and integrated control of soil erosion.

Since 2001, there have been some noticeable ecological improvements in areas where these key projects have been implemented. **Forest resources in China have been increasing constantly, with forest areas increased by 23%, compared with those of a decade ago**. A number of wetlands of national and international importance have been rescued and protected, with the protection rate of natural wetlands increasing by over 1% on the average annually. The area where mangroves and degraded wetlands in the near-shore coastal areas such as tidal flats have been restored has exceeded 2,800 km^2, as a result of an investment of 4.43 billion RMB. The area covered by soil erosion control reached 270,000 km^2 because of integrated control measures taken in 12,000 small river basins. The area enclosed for reforestation and conservation has reached 720,000 km^2, with initial ecological recovery occurring in areas of 450,000 km^2. Since 2008, the central government has allocated specialized funds of 19.5 billion RMB for rural environment improvement. These funds supported environmental improvements in 46,000 villages and more than 87 million people in rural areas benefited from these efforts. The implementation of key ecological projects has enhanced recovery of degraded ecosystems and habitats for wild species, thus effectively conserving biodiversity (Ministry of Environmental Protection, 2014).

Despite these on-going efforts challenges to conserve biodiversity and ensure sustainable agroecosystems still remain. Many natural areas and habitats are threatened, for example, about 90% of grasslands are experiencing different degrees of degradation and desertification; 40% of China's major wetlands are facing threats of severe degradation, especially mudflats and mangroves and according to the 2004 Red List, figures on endangered species is much worse than in previous assessments, with the number of endangered plant species far exceeding earlier estimates[22].

Within agricultural landscapes, soil erosion and pollution are widespread[23]. A census of arable land in China revealed that over a quarter is of poor quality, half of moderate quality and only one quarter high quality[24]. The main Pressures on soil quality arise from the use of agricultural chemicals[25], overgrazing[26] and agricultural management practices. Agricultural pollution is considered to directly threaten aquatic biodiversity and soil health[27].

22 https://www.cbd.int/countries/profile/default.shtml?country=cn
23 Wilkes, A. & Zhang, L. 2016. *Stepping stones towards sustainable agriculture in China – An overview of challenges, policies and responses*. International Institute for Environment and Development, London. Available at, http://pubs.iied.org/14662IIED.
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26 Liu, J. et al. 2010. Spatial patterns and driving forces of land use change in China during the early 21st century. Journal of Geographical Sciences 20 (4) 483–494.
27 China's Fifth National Report on the Implementation of the Convention on Biological Diversity: China: The Ministry of Environmental Protection of China, 2014. Available at, https://www.cbd.int/reports/nr5/.

The six case studies outlined below, further highlight the impact of agriculture on natural ecosystems at national and local scale. The impacts of other key drivers including urbanization are also highlighted.

3 Case studies on agricultural impacts in China

There is increased concern on the potential environmental effects from agricultural landscapes and agri-food systems, broadly. However, there is paucity of studies assessing environmental impacts of agri-food systems across the value chain in china. A **few studies conducted mostly at farm gate points towards significant impacts including land degradation, water and air pollution. Consequently, important ecosystem services including carbon capture, habitat provision as well as provisioning ecosystem services such as food and water are being negatively affected**. Six case studies are explored here in depth.

Case study 1: China's rapid economic development and increased agricultural production are key drivers to land degradation in China

Land degradation in China is increasingly recognized as an economic, social and environmental problem of great concern. Internationally, **the interlocking forces of climate and land use changes are considered as key drivers to land degradation**. Land degradation is caused by periodic stresses exerted by extreme and persistent climatic events and human induced activities through (1) **deforestation**; (2) **unsustainable agricultural land management practices** including the use and abuse of fertilizers, pesticides and heavy machinery and (3) **overgrazing, improper crop rotation and poor irrigation practices** (Sivakumar & Ndiang'Ui, 2007).

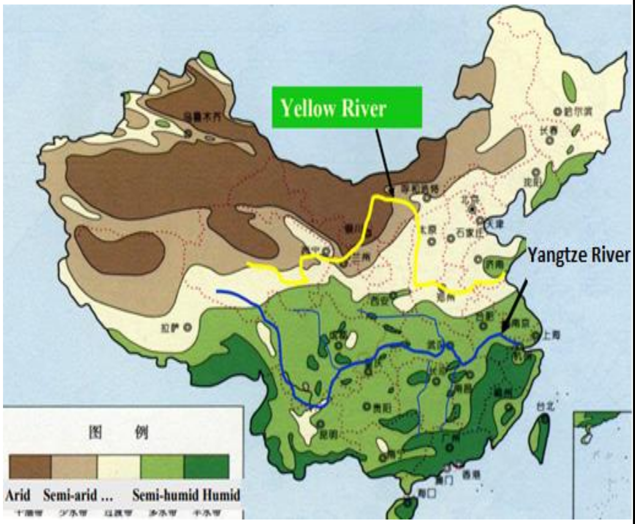
In China, **it is estimated that rapid population growth and urbanization, unreasonable human utilization and influence of natural factors, have caused degradation of 5.392 million km² land, accounting for about 56.2 % of the total national area**. The area of land degradation resulting from soil erosion and water loss, desertification, soil salinization, pasture degradation and soil pollution is 1.8, 0.33, 0.99, 2.0 and 0.27 million km², respectively (Long, 2013). Meanwhile, it is estimated that the suitable land for agricultural production is only about 1.3 million km², accounting for 14 % of the total land area in China. In relation to agriculture land, **more than 50 % of the total cultivated land has experienced land degradation**. This adds a further strain on agricultural production and is a threat to food security. In addition, **agricultural land degradation directly affects the potential land productivity and because of which more inputs such as fertilizer and irrigation water would be needed to get the same production and yield level** (Li et al., 2011). **This leads to an increase in the production costs and might exacerbate pollutions of soils and water resources**.

The Cost of land degradation in China

To assess the extent of the impact, a study by Deng and Li (2016) assessed the cost of land degradation and the cost of action and inaction against land degradation in China's agro-ecological zones and biomes, based on Land use/land cover change (LULCC) from 2001 to 2009. Figure 13 below shows China's agro-ecological zones (AEZ) and their predominant agricultural use.

Figure 13: China's agro-ecological zones and predominant agricultural use

Source: Lalonde and Sukigara (1997)



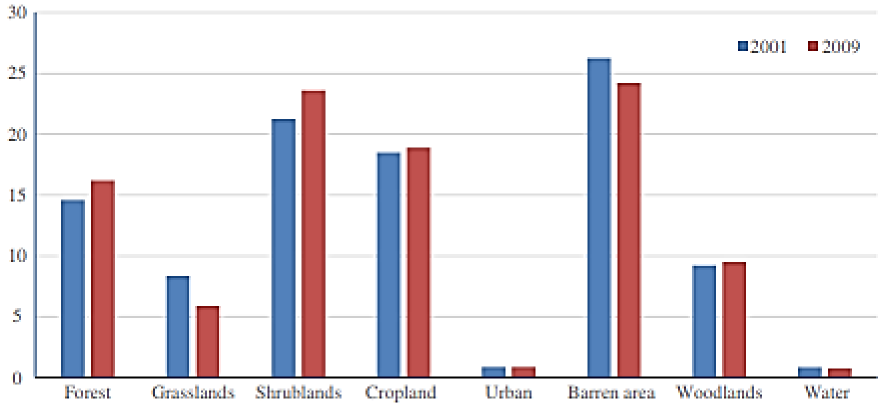
Source: Xia (2006)

As outlined in Section 2, these major agro-ecological zones can be described as follows. (1) The north and north west, generally mountainous and arid to semi-arid, is a predominantly pastoral region. (2) The centre extending to the north east of the country, warm (central) to cold (north east), is a mostly wheat and millet producing region. (3) The tropic and sub-tropic southern region is generally humid to semi-humid and where most crops are grown chiefly, rice.

(1) The cost of land degradation due to LUCC for the period of 2001–2009 and cost of action and inaction in China across degraded biomes

To assess the extent of the impact, a study by Deng and Li (2016) assessed the cost of land degradation and the cost of action and inaction against land degradation in China across agro-ecological zones and degraded biomes, based on land use/land cover data in 2001 and 2009 as shown in Figure 14.

Figure 14: Extent of land uses in China, 2001 and 2009



Source: Deng and Li (2016)

The total cost of land degradation due to Land Use and Cover Change (LUCC) for the period between 2001 and 2009 is presented in Table 11.

Table 11: The cost of land degradation due to LUCC for the period of 2001–2009 and cost of action and inaction in China across degraded biomes

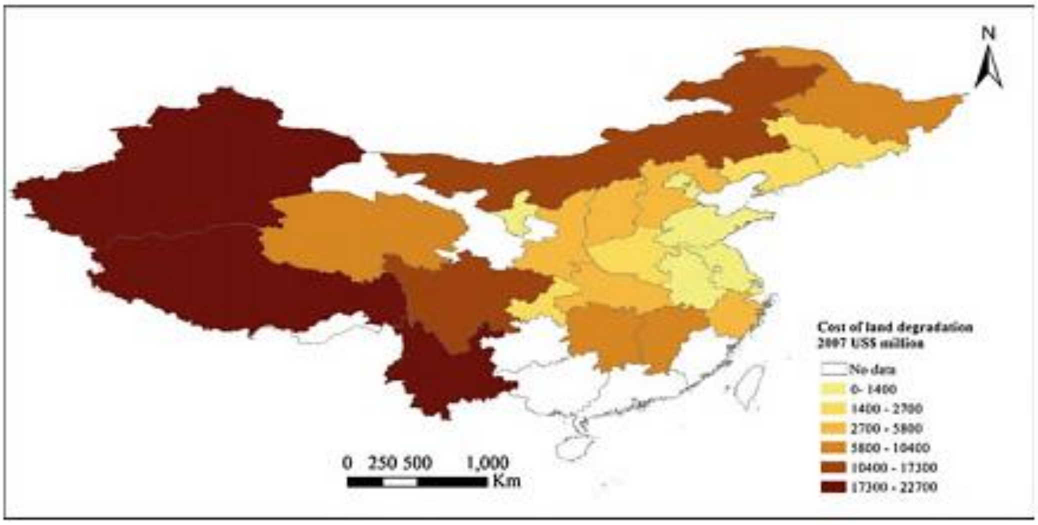
	Agro-ecological Zone			Total
	Arid and semi-arid	Sub-humid	Humid	
	2007 US$ billion			
• TEV	103.37	24.94	67.44	195.75
• Provisioning services	49.91	9.12	25.63	84.66
• Loss of provisioning services as % of TEV	48.28	36.57	38.01	43.25
Cost of restoration of degraded biomes				
• Forest	25.55	21.71	64.59	111.85
• Grassland	68.08	5.64	7.71	81.43
• Shrublands	12.70	4.22	7.49	24.41
• Woodlands	4.33	9.92	23.51	37.76
Cost of				
• Action	110.66	41.50	103.29	255.45
• Inaction	608.57	175.55	423.95	1208.08
MRR of taking action	5.5	4.2	4.1	4.7

Note: TEV is Total Economic Value and MRR is the Marginal rate of return
Source: Deng and Li (2016)

The total cost of land degradation in China due to LUCC for the period between 2001 and 2009 is estimated at about US$ 195.747 billion (in 2007 prices), accounting for 5.4 % of GDP. Annually, the cost of land degradation is estimated at US$ 24.5 billion per year between 2001 and 2009. **The cost of acting against land degradation, to completely rehabilitate the land degraded due to LUCC between 2001 and 2009 in China, was estimated at US$ 255.45 billion over a 30-year period.** On the other hand**, if action is not taken to rehabilitate these degraded lands, China would incur a loss of US $ 1208.08** billion during the same period. The **marginal rate of return (MRR) for investment in restoration of degraded land is above 4, suggesting very high payoff for taking action**. Restoration of degraded forest accounts for the largest cost. This is followed by restoration of degraded grasslands, especially in the arid and semi-arid areas in north-western China.

The spatial distribution of the total cost of land degradation to ecosystem services is highest in the arid and semi-arid area as shown in the Figure 15 below.

Figure 15: Total economic value of ecosystem services of major biomes (2007 US$ million)



Source: Deng and Li (2016)

The north and north west, generally mountainous and arid to semi-arid, is a predominantly pastoral region. Therefore, land degradation could largely be attributed to overgrazing.

(2) Cost of land degradation on grazing land

Today, livestock production accounts for 40 – 50% of the worldwide agricultural economy and constitutes a vital source of daily protein for people (Herrero et al., 2016). **One of the countries that have experienced notable increases in livestock production is China**. For instance, **the number of cows increased from 52.5 million in 1980 to 84.5 million in 2016; chickens from 0.9 million in 1980 to 5.2 million in 2016; and pigs from 325.7 million in 1980 to 456.8 million in 2016** (FAOSTAT, 2018). Unfortunately, livestock production is currently one of the major contributors to environmental pollution.

The increasing livestock population density and over-exploitation of grazing resources in response to the increasing demand for livestock product**s has resulted in land degradation**. The **cost of land degradation on static grazing lands was US$491 million** (2007 prices) as shown in Table 12.

Table 12: Cost of land degradation on grazing land (2007 US$ million)

Agro-ecological zone	Milk loss cost	Meat loss cost	Total cost	Percent of total cost
	2007 US$ million			
Subtropic-cool/semi-arid	20.59	21.74	42.33	8.6
Subtropic-cool/arid	10.53	11.55	22.08	4.5
Subtropic-cool/humid	0.12	0.04	0.16	0.0
Subtropic-cool/sub-humid	10.01	5.05	15.06	3.1
Temperate/semi-arid	33.26	33.48	66.75	13.6
Temperate/arid	100.56	230.03	330.59	67.3
Temperate/sub-humid	0.43	0.40	0.83	0.2
Tropic-cool/sub-humid	0.91	0.12	1.03	0.2
Tropic-warm/humid	5.61	0.86	6.46	1.3
Tropic-warm/sub-humid	5.09	0.63	5.72	1.2
Total	**187.11**	**303.90**	**491.00**	

Source: Deng and Li (2016)

The loss accounts for only milk and meat production. If other losses were considered, for example, carbon sequestration, the costs could be higher. The temperate arid area in the north-western region accounted for two thirds of the loss. Out of the total loss, meat loss also accounted for 62 % of the loss and the remaining 38% accrued to losses in milk production. This can be attributed to the fact that livestock production in temperate rangeland in the north-western China is mostly for meat production.

(3) Cost of land degradation on static cropland

China is among the countries that have the highest rate of fertilizer use in the world. According to estimates by Kahrl et al. (2012), China accounts for a third of the global consumption of inorganic nitrogen fertilizer. **The high rate of inorganic fertilizer application is considered the major cause of eutrophication and other environment consequences**. In northern China, concentration of nitrate in groundwater were found to be about 30 times the U.S. EPA recommended levels (Kahrl et al. 2012). At the same time, the adoption rate of organic inputs and integrated soil fertility management (ISFM) is still limited. Although no comprehensive assessment is available, the cost of land degradation to cropland could be substantial.

Considering maize, rice and wheat only, the cost of land degradation due to LUCC and land degrading management practices on static cropland at about US$12 billion (2007 prices) as shown in Table 13**.** According to the authors, the loss of carbon sequestration accounts for the largest share of total cost, due to limited use of organic inputs and continuous cropping systems.

The total cost of land degradation due to LUCC and using land degrading management practices on cropland and grazing land is 2007 US$37 billion or 1 % of China's 2007 GDP.

Table 13: The annual cost of land degradation on static cropland and grazing lands

Type of land degradation	Total cost (TEV)	Provisioning services	Cost of land degradation as % of GDP of 2007 US$3494.06 billion	
	2007 US$ billion		Total cost (TEV)	Provisioning services
LUCC	24.46	10.58	0.70	0.30
Livestock	0.49	0.49	0.01	0.01
Cropland	12.13	3.57	0.35	0.10
Total annual cost	**37.09**	**14.64**	**1.06**	**0.42**

Source: Deng and Li (2016)

The estimated costs of land degradation are conservative, given that the analysis did not include an exhaustive list of all major agricultural crops produced in China. Hence, for the long-term sustainable development of agricultural economy, it is critical to take sustainable productive land management measures.

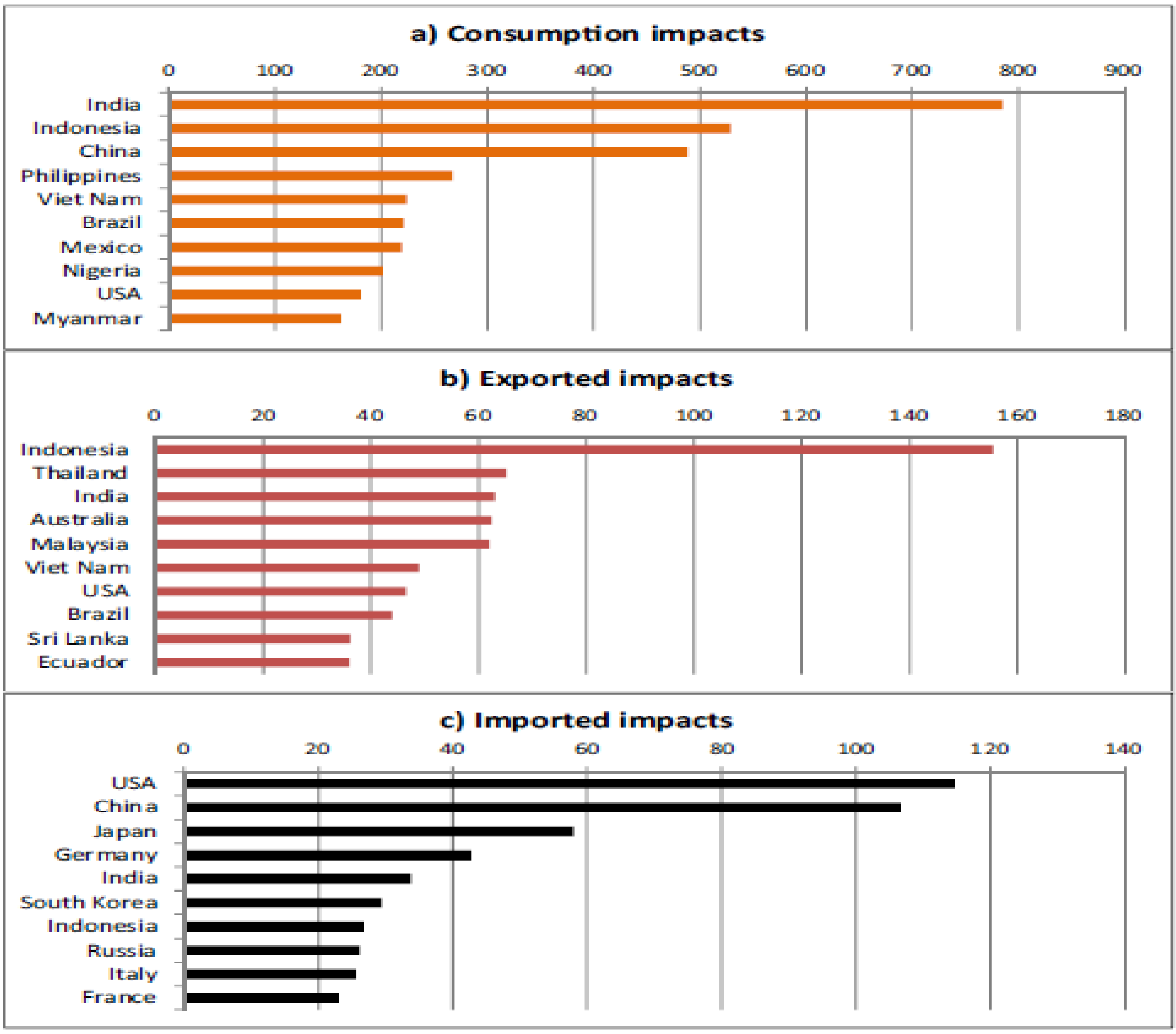
Case study 2: Agricultural land use to meet the demands of a growing population, changing diets, and lifestyles is a key driver of biodiversity loss in China

Biodiversity offers several benefits, including pollination and nutrient cycling, that are key to human health and the economy. Unfortunately, in the past 500 years, over 300 vertebrate species have been obliterated, and many more are under threat of extinction; and agriculture is a key driver of biodiversity loss (European Commission, 2016).

A study by Chaudhary and Kastner (2016) **employed the countryside species area relationship (SAR) model to estimate the mammals, birds, amphibians and reptiles species lost due to agricultural land use in 804 regions globally**. The study combined this measure of species lost with high spatial resolution global maps of crop yields to compute species lost per ton for 170 crops in 184 countries. Then, the study linked the impacts per ton with the bilateral trade data of crop products to calculate the land use biodiversity impacts embodied in international crop trade and consumption. Finally, the impacts per ton were multiplied by each country's volumes of current crop production (in tons) to identify which crop causes high land-use impacts. This process helped to identify the hotspots of biodiversity loss due to global agricultural land use.

The findings showed that **wheat, rice and maize land use contributed to 2,220 species lost (40% of global agricultural land use impacts)**. Such results did not come as a surprise because together these three crops occupy 40% of global cropland. Surprisingly, crops such as **sugarcane, palm oil, coconut, cassava, rubber and coffee contributed to 23% of global land use impacts,** which was quite high given that together they only occupy less than 10% of global cropland. Figure 16 shows the top-ranking countries for biodiversity impacts due to consumption, exports and imports.

Figure 16: Top-ranking countries for biodiversity impacts due to consumption, exports and imports (Unit: number of species lost)



Source: Chaudhary and Kastner (2016, p. 198)

Regarding the **top-ranking countries for biodiversity impacts, China is ranked 3rd on consumption and 2nd on imported impacts**. This highlights the fact that China's footprint on biodiversity is one of the highest in the world.

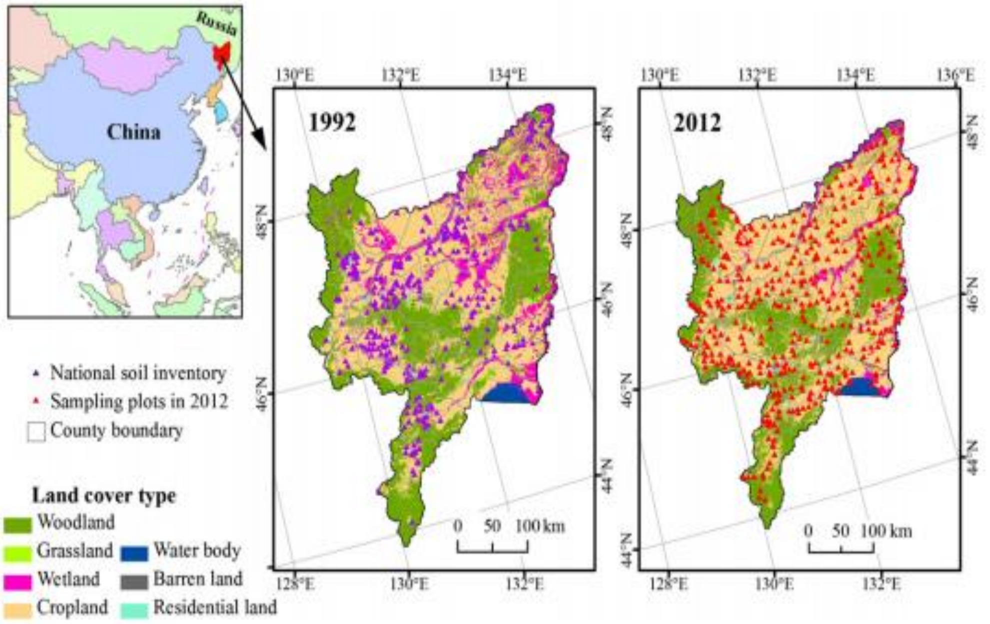
Case Study 3: Large-scale agricultural expansion: A key driver to ecosystem services and habitat loss in the Sanjiang Plain of China

The Sanjiang Plain is an important region in China for its large area of natural wetlands and intensive agriculture. It is located in the northeastern part of Heilongjiang Province (Figure 17). **Five sites in the Sanjiang Plain have been designated as wetlands of international importance**, namely the Honghe National Nature Reserve, the San Jiang National Nature Reserve, the Xingkai Lake National Nature Reserve, the Qixing River National Nature Reserve and the Zhenbaodao National Nature Reserve. It was estimated that in the 1940s, more than 50,000 km^2 of wetlands existed in this region. From the 1950s, land use practices significantly changed the original land cover, and the area experienced extensive reclamation that resulted in rapid losses in wetland area. For example, **from 1950s to 2000s, farmland area expanded by 250% and was mostly converted from natural wetlands**. As a result, **the**

Sanjiang Plain is now one of the most productive agricultural regions in China. However, **this has come at a great cost to natural ecosystems.**

Wang et al. (2015) assessed the extent of land use change and the associated impact on ecosystem services. **The ecosystem services assessed included water yield, ecosystem carbon stocks, suitable waterbird habitats and food production**. Figure 17 shows land use change between 1992 and 2012.

Figure 17: Land cover maps of the Sanjiang Plain and sampling sites in 1992 (a) and 2012 (b)

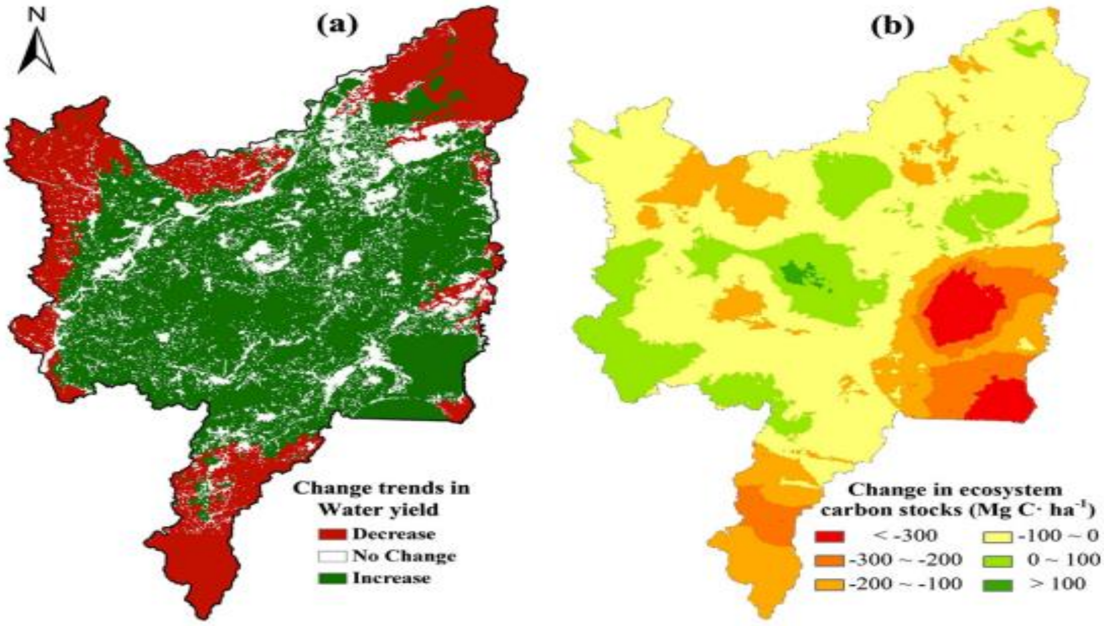


Source: Wang et al. (2015)

Farmland and woodland were the two largest land cover types in the study area, occupying more than 85% of the total area, and wetland was ranked as the third largest land cover type. Grassland, water body, residential land, and barren land accounted for only a small portion of the study area. The results also revealed significant changes in the land cover pattern of the Sanjiang Plain during the study period. The most remarkable change was **a decline in wetland (−53.32%) and an increase in farmland (+13.40%),** implying the conversion between these two land cover types. There was a slight decline of woodland (−1.87%) and **a significant increase of residential land (+105.54%).**

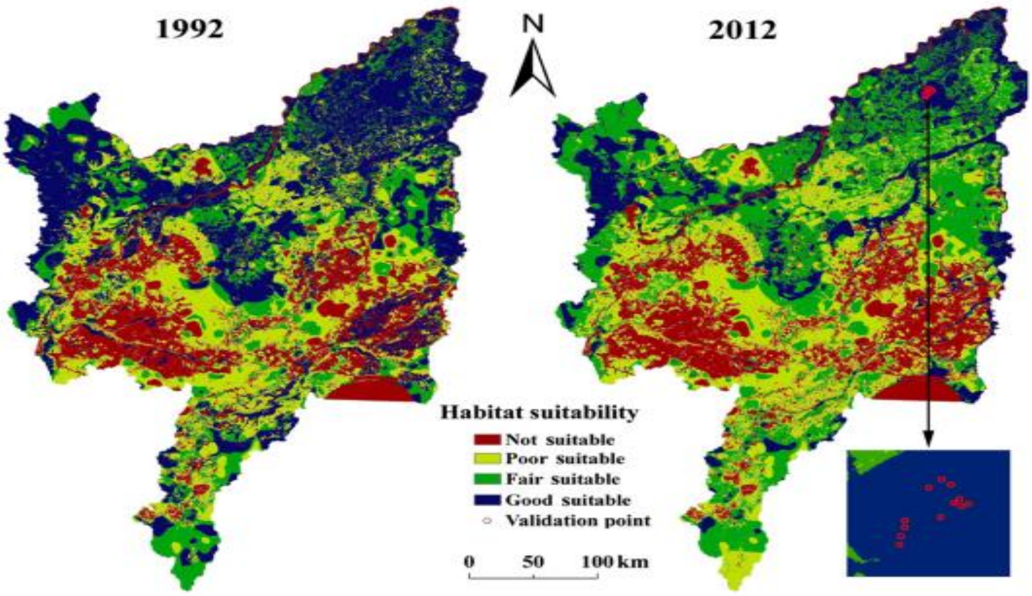
Figure 18 shows the impacts of wetland conversion on water yield (a) and carbon stock (b). Figure 19 shows changes in waterbird habitat suitability between 1992 and 2012.

Figure 18: Spatial distribution maps of water yield change (a) and changes in ecosystem carbon stocks (b) in the Sanjiang Plain



Source: Wang et al. (2015)

Figure 19: Maps of waterbird habitat suitability of the Sanjiang Plain in 1992 and 2012



Source: Wang et al. (2015)

The rates of change in these ecosystems services are further elaborated in Table 14.

Table 14: The rates of change in ecosystem services due to changes land cover type from 1992 to 2012

Land cover type	Woodland	Grassland	Wetland	Water body	Farmland	Residential land	Barren land
Area change (%)	−1.87	−17.35	−53.32	+1.23	+13.40	+105.56	−31.68
Change in water yield (%)	+13.10	−22.58	+16.54	−0.93	+15.07	−16.87	−50.00
Change in carbon stock (%)	−22.86	−33.18	−57.88	-	+0.90	-	-
Change in good and fair suitable habitat area (%)	+2.98	−7.57	−49.32		−74.20		−3.56
Change in grain production (%)	-	-	-	-	+192.44	-	-
Change in meat production (%)	-	-	-	-	+557.20	-	-
Change in aquatic products (%)	-	-	-	+349.00	-	-	-

Source: Wang et al. (2015)

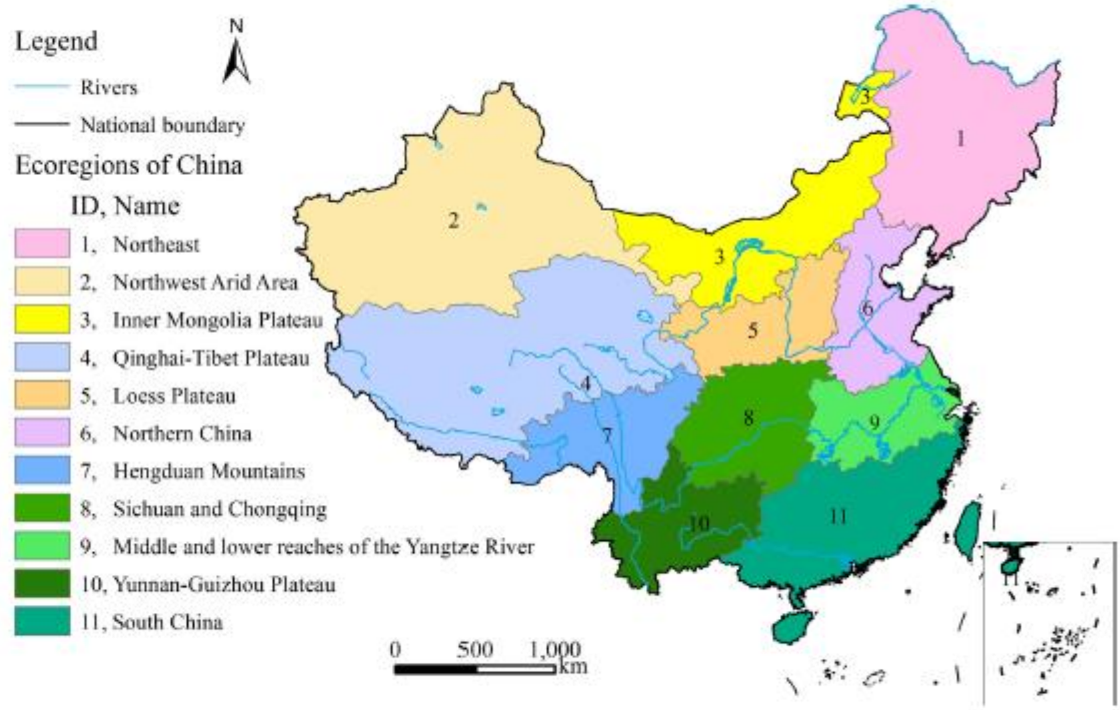
For regulating and supporting services, during 1992–2012, a 2% reduction in woodland area resulted in increased water yield (+13.10%) and declined ecosystem carbon stocks (−22.86%). A 17% reduction in grassland led to a reduction in water yield by about 23% and carbon stocks by 33**%. About 53% of wetlands were converted into other land cover types, mainly farmland and residential land.** This had a substantial impact on ecosystem services, **with a loss of about 50% of carbon stocks and almost 60% loss in suitable waterbird habitats**. In contrast, wetland shrinkage increased water yield. **Farmland expansion led to a 74% loss on suitable waterbird habitats**, but increased water yield by 15%; while **residential expansion (+105.54%) led to water yield decrease by 17%.**

For provisioning services, farmland expansion also substantially enhanced production of grain and meat. The analysis highlight that while land cover changes may seem economically profitable, land conversion from natural ecosystems have the potential to deplete the ecosystem's capacities to deliver ecosystem services. Ultimately, medium- and long-term losses may exceed these short-term gains.

Case Study 4: Climate change coupled with land conversion to agriculture and urbanization are key drivers to ecosystem services change in China

China has a diverse range of ecosystems are divided into different terrestrial ecoregions. **At national level, Zhang et al. (2017) carried out a study to identify the spatial and temporal dynamics of ecosystem services and driving factors from 2000 to 2010.** The ecoregions used in their study are presented in Figure 20.

Figure 20: Locations of ecoregions in China

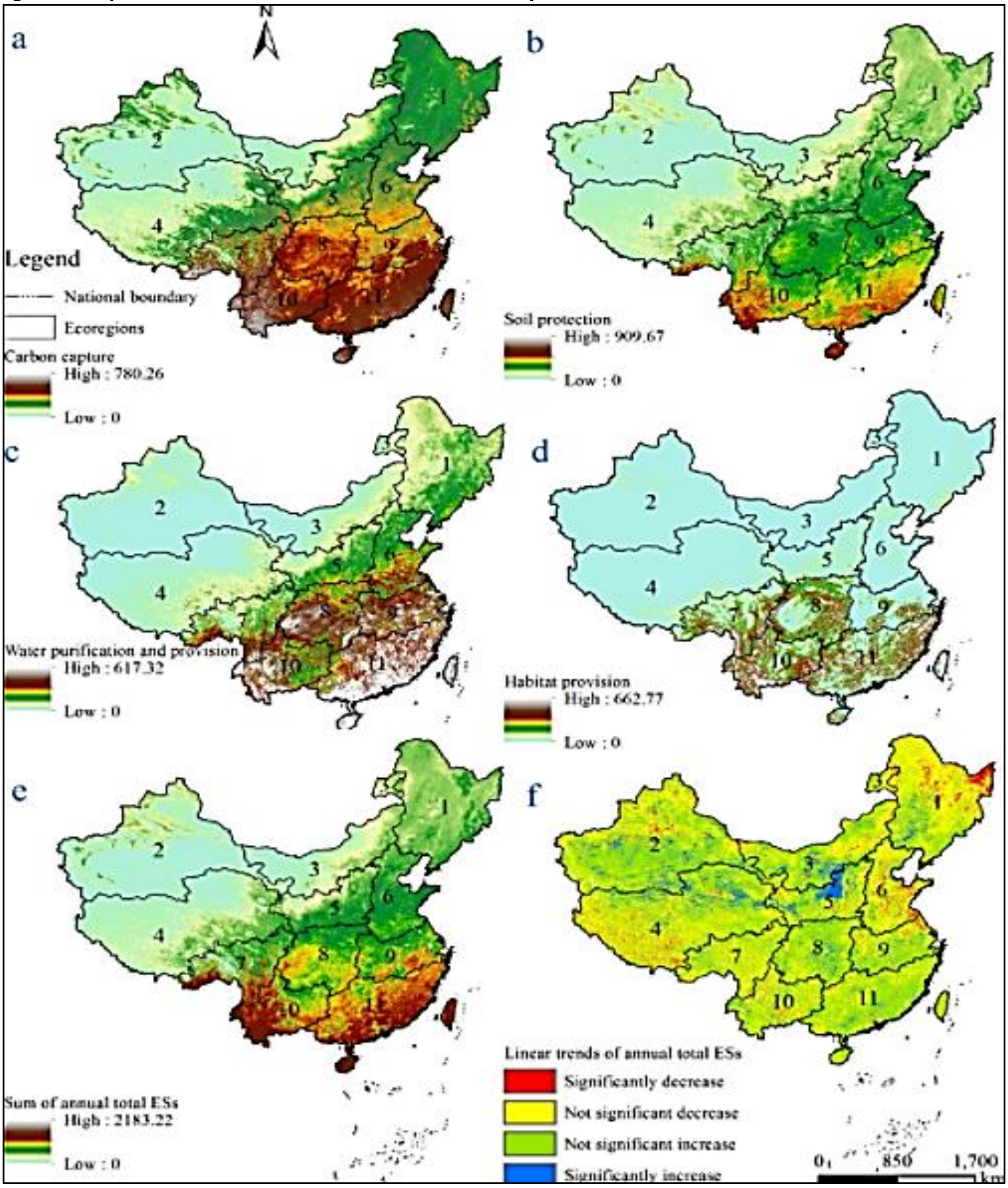


Source: Zhang et al. (2017)

The ecosystem service provision mapped in their study included carbon capture, soil protection, water purification and provision, and habitat provision.

Figure 21 shows the spatial distributions and linear trends of ecosystem services (ESs) in China from 2000 to 2010. Figure 21(a–d) shows the spatial patterns of carbon capture, soil protection, water purification and provision, and habitat provision ESs, which are the average of the annual single ES from 2000 to 2010. Figure 21(e) shows the sum of the average of the annual four types from 2000 to 2010. Figure 21(f) presents the linear trends of annual total ES from 2000 to 2010.

Figure 21: Spatial distributions and linear trends of ecosystem services in China from 2000 to 2010.



Source: Zhang et al. (2017)

This study results in Figure 11a–c, and e show that: (1) **the average annual total value of ESs provided from 2000 to 2010 increased from northwest to southeast, and in the middle and lower reaches of the Yangtze River (ecoregion 9) as well as over the entirety of the Yunnan-Guizhou Plateau (ecoregion 10) and South China ecoregions**; (2) the temporal trends of annual total ESs from 2000 to 2010 **showed increases in most ecoregions except those of northeast China and northern China, which experienced decreases**.

Climate factors, land conversion to farmland and urbanization were found to be the main drivers to ecosystems services change. It was further found that the **decline of sum-total ES in the south of the**

Qinghai-Tibet Plateau, the central part of Yunnan- Guizhou Plateau, the north of Northwest Arid Area and the east of the Inner Mongolia Plateau ecoregions was caused by the climate factors. Whereas, **the decline of total ESs in the north of Northeast China** were partly because of **climate changes** and due to **increased forest conversion to farmland** during the study period. In the **south of the Loess Plateau and the Northern China ecoregions urban land use expanded very rapidly**. Consequently, ecosystem services decreased with the loss of natural land cover in these regions. In the north of the Loess Plateau ecoregion (ecoregion 5), where farmland was converted to grassland or forest under the promotion of the Grain for Green Project, vegetation in the area recovered significantly and therefore the ESs of this area also increased significantly.

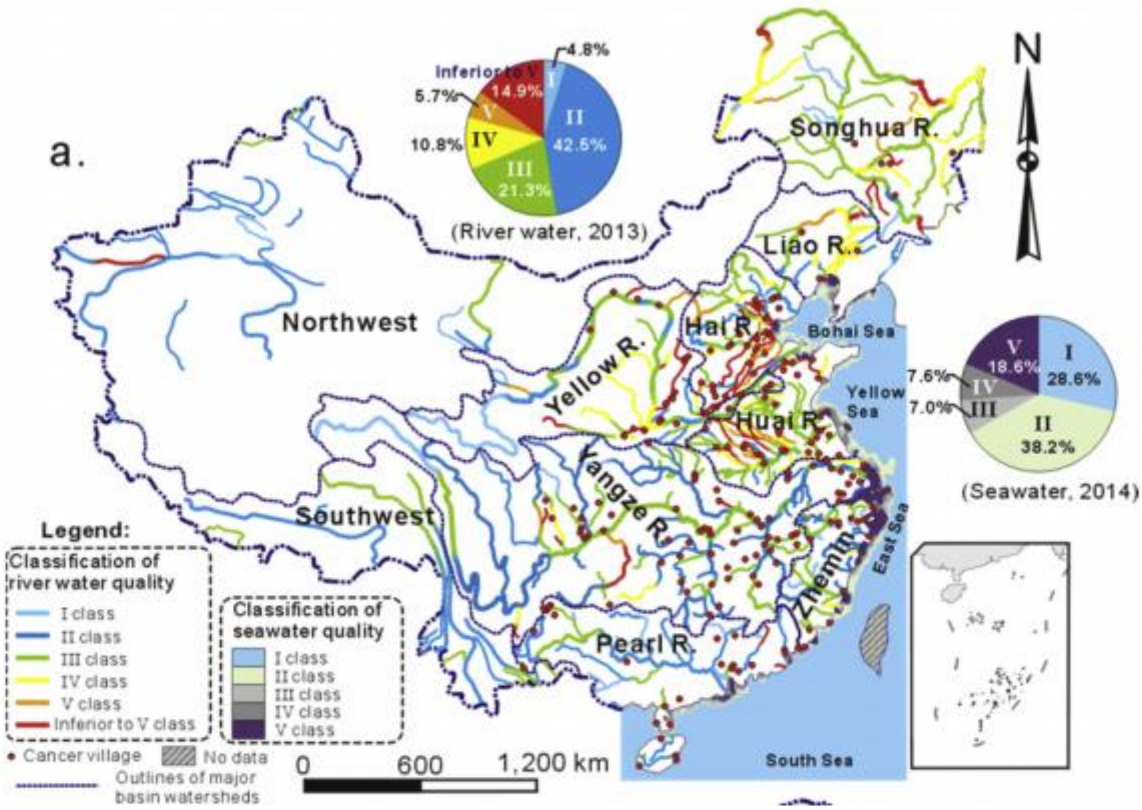
Case Study 5: Agriculture among the key drivers to water pollution in China

China faces one of the most serious water shortage and pollution crises. China's groundwater and surface water are recognized as being among the most severely degraded natural resources in the country and among the most heavily polluted water sources in the world (Han et al., 2016; Shapiro, 2012).

Han et al. (2016) constructed pollution maps of the surface water and groundwater environments at the national scale based on recent government statistics as shown in Figure 22 and Figure 23, respectively. Water quality in China is assessed according to a five or six class ranking system under the Environmental Quality Standards.

Presently, it is reported that out of 208,000 km of monitored river reaches in China, water quality in 31.4% reaches falls into class IV or worse and therefore, unfit for potable use or human contact. Water quality in 14.9% of river reaches is inferior to class V, indicating complete loss of potential for all consumptive uses or human contact. Of the ten major watershed areas, only in the southwest and northwest is water quality in most rivers rated as high to moderate (Classes I to III), while the major northern river systems including the Yellow, Liaohe, and Huaihe rivers are rated as class IV or V, and the Haihe river as class VI (Figure 22). Water in six of nine major coastal bays in China is characterized as 'poor' or 'very poor' (Classes IV or V). In autumn 2014, the combined coastal area with water quality in class IV or V (unfit for human contact) covered 57,000 km^2. These areas are at the discharges of river systems that drain China's major industrial and agricultural regions, integrating numerous upstream pollution sources.

Figure 22: Surface water (major rivers and seawater) ranked according to the 6-class water quality classification (GB 3838-2002) and seawater quality of offshore areas ranked according to the 5-class classification (GB3097-1997)

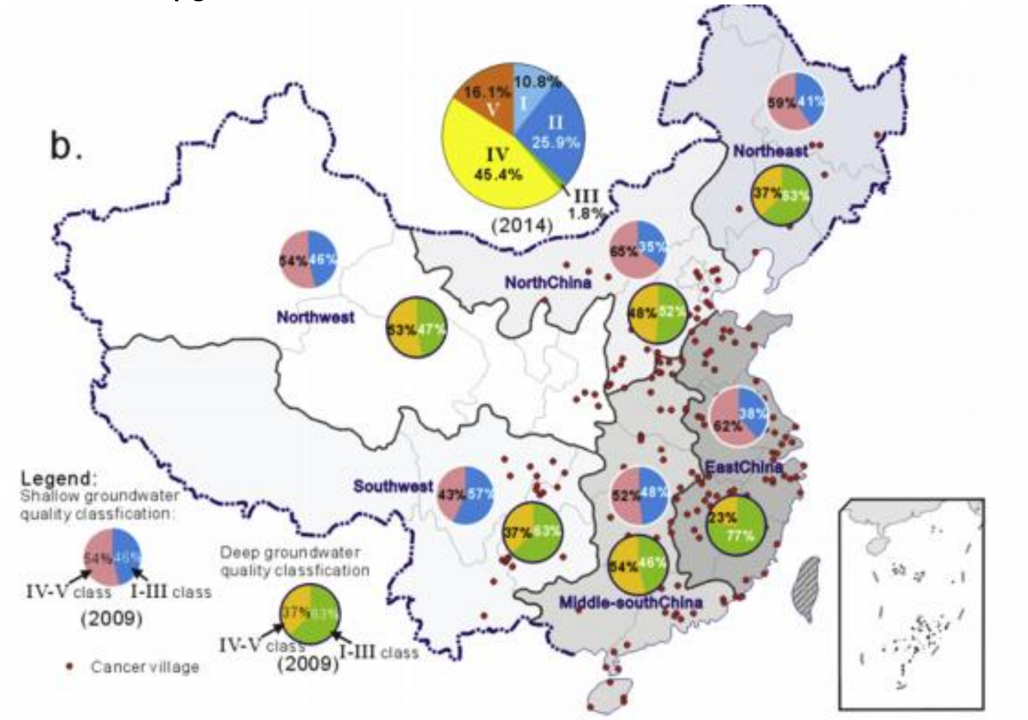


Source: Han et al. (2016)

Figure 23 shows **the most detailed nation-wide data for groundwater pollution** currently available in government statistics, using China's 5-class groundwater quality rating standard. Overall percentages in each class for each water source in China are shown as the large pie-charts. **Percentages shown in yellow and red on the smaller pie-charts in Figure 23 indicate the proportion of samples in the lowest two classes (IV & V) for shallow and deep groundwater, respectively**.

In China, **groundwater accounts for one-third of total water usage across the domestic, agricultural and industrial sectors**. It is estimated that approximately two-thirds of cities utilize groundwater as a major water supply. According to the latest Bulletin of Land and Resources of China (2014), **groundwater from 61.5% of 4896 monitoring wells in 202 cities across China was characterized as poor (IV class) or very poor (V class)**. Furthermore, the 2014 estimates by the Ministry of Land and Resources showed that **about 80% of groundwater samples taken from more than 2000 shallow groundwater monitoring wells in China's northern basins falls into classes IV and V**. According to the national groundwater quality standard (GB/T 14848-93), water at or below Class IV is unfit for domestic or agricultural uses (Han et al., 2016).

Figure 23: Groundwater ranked using the 5- class system (GB/T14848-93) in 6 sub-areas of China, including shallow and deep groundwater

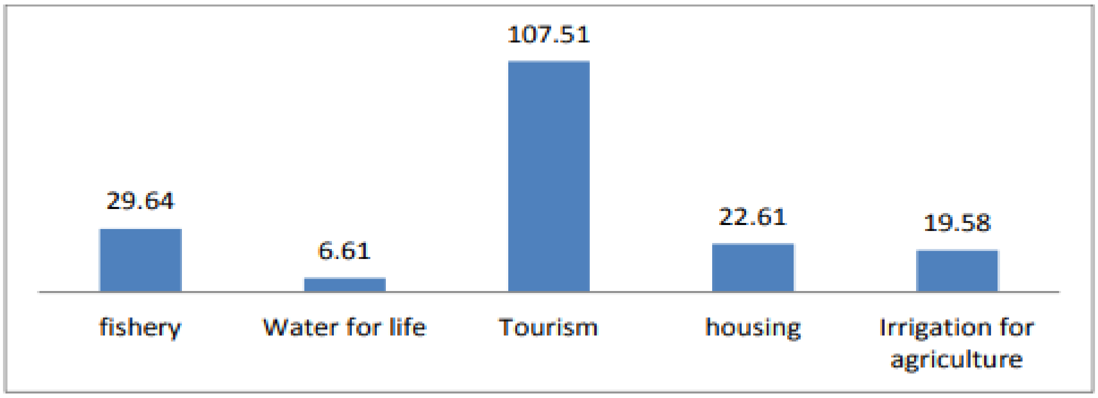


Source: Han et al. (2016)

The major sources of surface water and groundwater contamination in China include unregulated sewage and municipal wastewater discharge, industrial wastewater discharge and agricultural fertilizers and pesticides. Studies carried out on pollution load by source indicate that on aggregate, **agricultural sector pollution outweighs urban and industrial sources in terms of major water quality indicators such as nitrogen (as nitrate, nitrite and ammonia) and phosphorus** (Watts, 2010). However, this varies by region depending on land cover and land use type. For example, areas in the northwest of China and North China Plain are intensively cultivated, and nitrate contamination from excess fertilizer appears to be one of the dominant sources in these areas (Han et al., 2016).

Research into the costs of water pollution points towards significant economic losses to the economy. For example, **a study Zhang (2014) estimated economic costs of water pollution in the Yangtze River to the Chongming County from 2005 to 2013 to be RMB 6.61 -107.5 billion**. The economic **cost of pollution for irrigation in agriculture was estimated at almost RMB 20 billion** as shown in Figure 24.

Figure 24: Total economic loss per function from 2005-2013 in Chongming County (unit: RMB100 million)



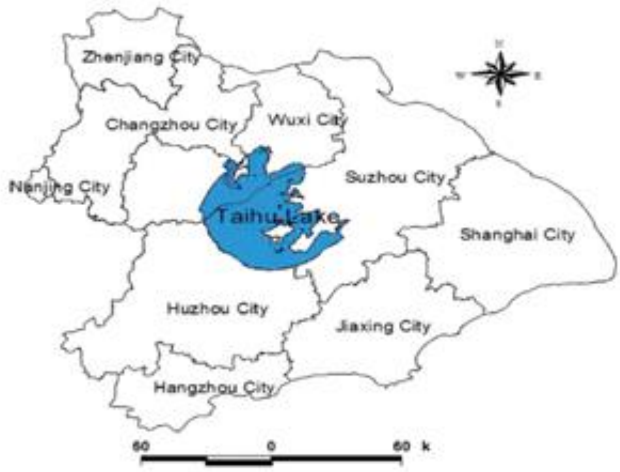
Source: Zhang (2014)

To address water pollution problems, in 2014, the Chinese Premier, Li Keqiang publicly declared 'war on pollution'. Since then, **the Central Government of China announced major policies on pollution control and remediation. The Water Pollution Prevention and Control Action Plan ("10-Point Water Plan") was released in April 2015** (Central People's Government of the People's Republic of China, 2015). Promotion of more sustainable practices in agroecosystem as envisaged by the TEEB project could complement these efforts.

Case Study 6: Rice production system in Taihu region is a key driver to potential aquatic eutrophication, water depletion, global warming, acidification, and energy depletion.

Taihu Lake region in the eastern part of China (Figure 25), is one of the most intensively cropped areas. The arable lands in this region are dominated by a rice–wheat rotation system.

Figure 25: Location of Taihu region



Source: Wang et al. (2010)

- **Taihu Lake is the third largest freshwater lake in China.**
- The amount of N and P inputs in this region has significantly increased in the past two decades.
- **N and P inputs are considered among the key contributors to the eutrophication of Taihu Lake** (Wang et al., 2010).

A study by Wang et al. (2010) used a life cycle assessment (LCA) method to assess the environmental impact of the rice production system in Taihu region, China. The LCA considered the entire system required to produce 1 ton of rice including raw material extraction and transportation, agrochemical production and transportation, and arable farming in the field. **The rice production system was divided into three subsystems: raw material extraction and transportation (RMET), agrochemical production and transportation (APT), and arable farming (AF)**. The production processes of machines, pesticides, buildings, and roads were excluded from the analysis because of a lack of data.

The result shown in Table 15 shows the extent of environmental impacts of rice production systems on energy and water depletion.

Table 15: Life cycle energy and water depletion of the rice production system

	Raw material extraction and transportation (RMET) subsystem	**Agrochemical production and transportation (APT) subsystem**	**Arable farming (AF) subsystem**	**Total**
Energy depletion (MJ/ton)	133 (3.7%)	3287 (93%)	106 (3%)	3526
Water depletion (t/t)	0.4 (0.09%)	51(11.8%)	379.7(88%)	431.1

Source: Wang et al. (2010)

Agrochemical production and transportation contributed 93% to the total fossil fuel consumption per ton of grain (Table 15). Water depletion consisted of paddy irrigation water consumption, water consumption of the N fertilizer industry, and water consumption of raw materials exploitation. **The water depletion potential in arable farming subsystems was 379.7 tons, accounting for 88% of the life cycle water depletion of the rice production system**.

The environmental impacts on global warming, acidification and eutrophication potential of rice production systems are presented in Figure 28, Figure 28and Figure 28.

Figure 28: Life cycle global warming potential of rice

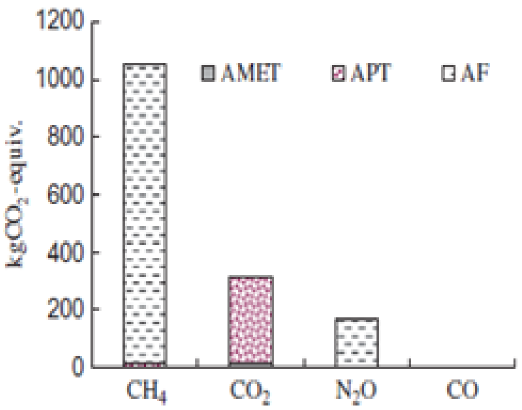


Figure 28: Life cycle acidification potential of rice

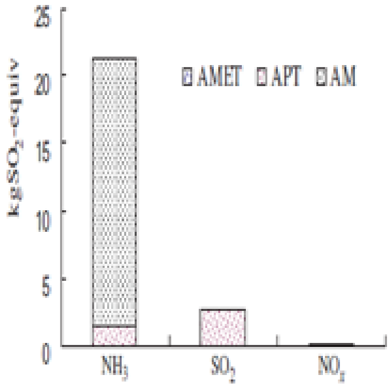
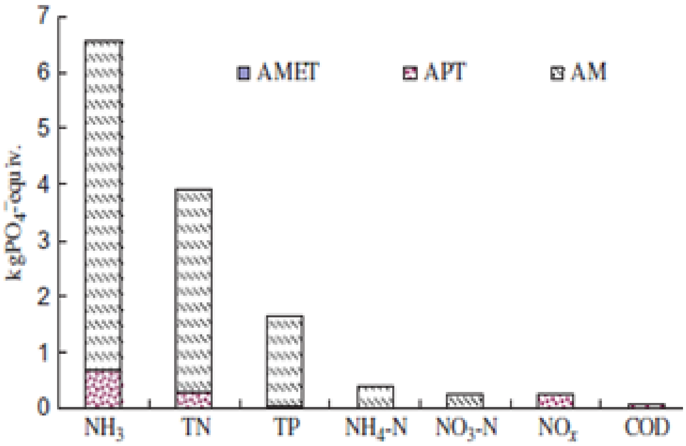


Figure 28: Life cycle aquatic eutrophication potential of rice



Source: Wang et al. (2010)

The global warming potential of the rice production system is dominated by CH4 and CO2 (Figure 28), which contributed about 68% and 21%, respectively to the total global warming potential per ton of rice. CH4 was emitted mainly from the Arable farming (AF) subsystem. In contrast, CO2 was emitted mainly from the Agrochemical production and transportation (APT) subsystem for agrochemicals, the most energy intensive product.

The acidification potential of the rice production systems results primarily from NH3 volatilization in arable farming subsystems(AP) and SO2 emissions in agrochemical production and transportation (APT). **The arable farming (AP) subsystems accounted for nearly 93% of the total acidification potential of the rice production system.**

In relation to **aquatic eutrophication potential (AEP), nitrogen (N) loss through ammonia volatilization constituted a very large proportion of the N fertilizer loss from the rice production system, accounting almost 60% of the total AEP**. In addition, N runoff losses from the arable farming subsystem was another important pollutant causing aquatic eutrophication, accounting for 25% of the total AEP (Figure 28).

Research into environmental and cost saving benefits from sustainable agriculture in China is also evolving. There are a number of case studies on this strand of investigation. Only one case study is outlined below.

Case Study 7: Environmental benefits and production performance of organic farming in China

Organic agriculture has been promoted as an environmentally friendly alternative to conventional agriculture. In organic production system, the use of synthetic inputs (synthetic fertilizers, pesticides, and additives) are dramatically reduced. Consequently, leading to sustained health of the ecosystem and human beings by relying on processes and cycles of ecological biodiversity adapted to local conditions (IFOAM, 2014).

In China, **organic agriculture has been on the rise since the 1990s, with** increased domestic and international demand for organic products as key drivers. In 2013, organically managed farmland accounted for approximately 0.97% of national arable land, covering 1.158 million ha (Meng et al., 2017). **By 2015, China was ranked fifth among countries with the largest areas of organic agricultural land** (Willer & Lernoud, 2017).

At national scale, a study by Meng et al. (2017) assessed the environmental benefits and production performance of organic farming in China. Their study utilized the 2013 data of organic production obtained from a national survey organized by the Certification and Accreditation Administration of China. In addition, farming performance and environmental impact indicators were screened and indicator values were defined based on an intensive literature review and were validated by national statistics.

The economic (monetary) values of farming inputs, crop production and individual environmental benefits were then quantified and integrated to compare the overall performances of organic versus conventional agriculture as shown in Table 16.

If organic crop yields were assumed to be 10%-15% lower than conventional yields, **the environmental benefits of organic agriculture (a decrease in nitrate leaching, an increase in farmland biodiversity, an increase in carbon sequestration and a decrease in greenhouse gas emissions) were valued at 1921 million RMB** (320.2 million USD), or 1659 RMB (US$ 276.5) per ha. By reducing the farming inputs, **the costs saved was 3110 million RMB** (US$ 518.3 million)**,** or 2686 RMB (US$ 447.7) per ha. The **economic loss associated with the decrease in crop yields** from organic agriculture was valued at **6115 million RMB** (US$ 1019.2 million), or 5280 RMB (US$ 880) per ha.

Table 16: Environmental benefits from organic agriculture

Total environmental benefits		Cost saved from reduced farming inputs		The economic loss:	
From a decrease in nitrate leaching, an increase in farmland biodiversity, an increase in carbon sequestration and a decrease in greenhouse gas emissions		Reduction of pesticide use and synthetic fertilizer in organic agriculture		From a decrease in crop yields from organic agriculture	
Total environmental benefits	Environmental benefits/ha	Total cost saved	Cost saved/ha	Economic loss from decreased yield	Economic loss/ha
1921 million RMB (US$320.2 million)	1659 RMB (US$276.5)	3110 million RMB (US$518.3 million)	2686 RMB (US$447.7)	6115 million RMB (US$1019.2 million)	5280 RMB (US$880)

Source: Meng et al. (2017)

As highlighted by authors the estimates provided above are conservative owing to the complex relationships among farming operations, ecosystems and humans. However, **the production costs saved and environmental benefits of organic agriculture quantified compensated substantially for the economic losses associated with the decrease in crop production.**

The case studies outlined above are not exhaustive, but highlight the current and potential future impacts of the agriculture on natural ecosystems and biodiversity. The case studies, further highlight the need to strengthen conservation efforts in the agriculture sector.

4 Conclusion

Over the past three decades, the economy of China has grown substantially making it the largest economy in the world, in terms of the purchasing power parity. Though **the agriculture sector's contribution to GDP has declined over time, it remains the mainstay of the economy**. China remains the largest agricultural economy in the world. The agriculture sector employs 28.3% of the 1.4 billion Chinese. China is **number one global producer of rice, wheat, potatoes, fruits and vegetables, peanuts, tea, millet, barley, cotton, oilseed and soybeans**. However, **China's agriculture sector has a large environmental footprint and a key threat to biodiversity loss.**

Presently, **agriculture in China is facing the challenge of feeding an escalating human population (1.4 billion) under increasingly declining soil quality, land and water scarcity, and water and air pollution.** Although China is undertaking many steps to halt and reverse the pressures on the environment and biodiversity arising from the agri-food sector, there is a long road ahead to close the gap between aspiration and application. The case studies investigated reveal the potential for complex trade-off between social- economic and environmental objectives in the China's agri-food systems. Research into this area is still evolving, with an evaluation of possible trade-offs mainly focused at farm level. More comprehensive analysis of potential social- economic and environmental trade-offs is generally constrained by the complexity of the agri-food value chains and data availability.

An understanding of these trade-off is crucial for the effective implementation of China's sustainable agriculture initiatives. **The UN Environment TEEB project on "Promoting biodiversity and sustainability in the agriculture and food sector in China"** complements the Government green growth initiatives by **highlighting several trade-offs made in land-use decisions and mainstreaming the values of biodiversity and ecosystem services values in decision-making**.

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