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China's response to a national land-system sustainability emergency

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Supplementary Information

China's unprecedented response to a national land-system sustainability emergency

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Supplementary Methods

Review, synthesis, and information assembly

We undertook a comprehensive review and synthesis of 16 major sustainability programs in China. Programs were selected based on the level of investment and area, both planned and actual, in addressing the sustainability of land systems. We selected programs addressing a range of geographies, socio-economic and environmental contexts, and land sustainability issues including soil erosion and river sedimentation in the Yellow and Yangtze rivers, desertification in northern China and southern karst systems, land consolidation and cropland development, forestry, and grassland and rangeland systems. We acknowledge that other significant sustainability programs were also established during this time such as the Returning Grazing Land to Grassland Program⁶²; the Eco-compensation for Watershed Services program¹⁴¹; projects linked to REDD+¹⁴² and the Clean Development Mechanism¹⁴³; and wetland conservation programs¹⁴⁴. Other environments were also the focus of investment such as coastal reclamation. However, these were beyond the scope of our review.

We assembled a multidisciplinary team of 19 scientists from 16 institutions from China, Australia, and the US. This provided both the capacity to cover both the Chinese and English literature, and the diversity of expertise required to understand the complex and heterogeneous socio-cultural, economic, and environmental settings relevant to China's investment in sustainability. Our collective expertise spanned forest ecosystems and conservation; landscape ecology; reforestation and carbon dynamics; restoration ecology; grasslands, rangelands, and livestock systems; dryland and desert systems; soils, hydrology, and erosion; land degradation and development; ecosystem services; environmental policy and instrument design; resource economics; and sustainability. The team met face-to-face at a workshop in Beijing in November 2016.

For the 16 Chinese sustainability programs reviewed, we synthesised and summarized the governance arrangements, aims and objectives, time frames, planned investment, geography, implementation mechanisms, performance to-date, unintended consequences, monitoring, and level of community engagement for each program (Supplementary Tables 1–16). Programs were managed by several government agencies at multiple levels including central, provincial, and local

government and hence, no single authoritative and quantitative source of program information existed. We used a multi-source review approach which involved assembling information from over 150 individual sources of published scientific and grey literature including: a combination of official government reports, yearbooks, and statistics; scientific journal papers and reports, academic theses, news articles, and webpages (Supplementary Table 17). Many of these sources were published in Chinese.

The quantitative methods used were simple. We compiled data on the level of financial investment and the area of coverage of sustainability interventions predominantly from official statistics published in government yearbooks and supplemented by the sources described above and detailed in Supplementary Table 18. Data was entered manually, and validated using a 2-step quality control process where the data was checked by multiple individual coauthors. Where available, data was disaggregated by province (or autonomous region), year, and type of on-ground actions. The few remaining data gaps were filled using trends or averages (Supplementary Table 17). Because the total investment and area were low from 1978–1997, we presented aggregated data for the decades 1978–1987 and 1988–1997 as average values in the annual graphs and as summed values in the cumulative graphs. These decadal values were allocated spatially to provinces according to the average proportion observed from 1998–2014. Actual investment data was converted from Chinese yuan (RMB) to 2015 US dollars (USD) using the exchange rate¹⁴⁵ and Consumer Price Index^{146,147} from each year.

Review of program impacts

Our aim in this section was to illustrate the broad impacts of China's integrated portfolio of sustainability programs across seven key indicators including forests and grasslands, desertification and dust storms, soil erosion, water, biodiversity, agriculture and food, and society and economy. Indicators were selected based on the stated aims of the programs. The indicator list is not comprehensive due to space limitations and several important indicators have been omitted (e.g. carbon sequestration, soil health, climate, forest resources). We opted for a narrative-type, targeted critical review and synthesis methodology rather than a full systematic review protocol for several reasons:

- The scale of the task of systematically reviewing the impact of 16 programs on 7 indicators and limitations on space is prohibitive and beyond the scope of the paper.
- Capturing the complexity and heterogeneity in impacts across space, time, and between programs demanded a more nuanced, critical, and discursive approach.
- Variation in the quality of methods used by published studies demanded the careful evaluation and targeting of high-quality studies.
- The degree to which each program has been evaluated varied widely. Some have been studied extensively (e.g. Grain-for-Green socio-economic impacts) while others have not been evaluated at all.

Rather than a formal systematic literature search, our review strategy included targeted studies that provided a national overview, complemented by local, detailed, case studies. In reviewing sustainability impacts, Web of Science and Google Scholar searches were undertaken using the terms “China” AND “program*” and one or more terms specific to each indicator (e.g. “desertif*”, “erosion”). All papers were screened for methodological quality, with studies which use causal approaches (e.g. setting up counterfactuals, controlling for confounding factors etc.) preferred to those demonstrating association only. Studies published in English journals of higher impact-factor, more recently, with more citations were preferred. Other papers were also identified in second and

subsequent rounds via inspecting the reference lists of recent key papers and parsed through the same process until arriving at a relatively comprehensive and high-quality literature selection for each indicator. For each indicator, many more references were consulted beyond those cited to ensure that our interpretation was representative of the broader literature.

Mapping program investment to UN Sustainable Development Goals

We mapped the investment and impacts of each of China's 16 major sustainability programs to the 17 UN Sustainable Development Goals and the 169 targets³ underpinning them using a qualitative weighting method. We comprehensively considered the aims and objectives of each program (Box 1), the nature of the actions supported (Supplementary Tables 1–16), the scale of investment and area (Supplementary Tables 19–21) of on-ground actions, and the resultant impacts (see "Program impacts" section). We then assigned weights mapping each program to each SDG based on the degree of alignment with the targets specified under each SDG³ (Supplementary Table 18). Investment in one aspect of a program (e.g. afforestation) may contribute simultaneously to multiple SDGs (directly or indirectly, primarily or secondarily, and positively or negatively). A weight can be positive or negative, depending on the relative impact the program had on a SDG. If the program had both positive and negative impacts on one SDG, a net weighting was calculated as the positive impact weight minus the negative. Weights were then multiplied by the total program investment to arrive at a level of investment in each SDG for each program. These values were then summed to indicate the level of investment in each SDG through China's sustainability programs.

Limitations

Much of our data relies on official government-reported statistics and we take this published data at face value. However, the data includes inherent potential for error and bias^{80,148}. While *investment* levels may be misreported for multiple reasons, there seems to be greater potential for error and bias in reported *area* statistics. Monitoring and reporting the actual area of sustainability interventions is typically undertaken at the local government level via field visits and on-site survey. The sheer vastness of the areas involved and the remoteness and inaccessibility of the locations means that this task is often difficult, time-consuming, and subjective¹²⁵. In addition, area statistics can be used strategically by local officials to exaggerate program success, and mask underperformance and failure¹⁴⁸. The incentive for landholders is to exaggerate reported areas of on-ground works to increase payments. Statistics do not account for failed interventions (e.g. low plant survival rate)⁸⁰, or land once subject to sustainability interventions such as reforestation, then reconverted to its original use or to other uses such as urbanisation or illegal logging¹⁴⁹. With the broad definition of forest used in China's statistical reporting, a range of land-uses can be included (e.g. unstocked land, cleared land designated for forest) which may not actually support tree cover¹⁵⁰. Further, as multiple programs fund similar sustainability interventions in the same areas, the same area of on-ground works could potentially be counted towards two or more programs, or *why not marry three times?* as the Chinese saying goes. Some studies have found that reported areas of reforestation varied substantially from the actual area reforested^{125,150,151}.

Remote sensing studies have been widely used to independently detect the extent of sustainability interventions in China and these can potentially overcome some of the above limitations with error and bias in area reporting. However, remote sensing approaches are also imperfect. Remote sensing can provide higher spatial resolution information than statistical data sources, but lower resolution on the types of sustainability actions undertaken. Most remote sensing these studies have focused on reforestation as other interventions such as avoided deforestation, natural regeneration, and changes in agricultural management are much more difficult to detect remotely. All remote sensing studies include error whether it is made explicit or not. Actual areas reported by remote sensing studies are

affected by terrain as steep hillsides, where much of the targeted land occurs, appear smaller from above due to the angle of incidence. Some reforestation such as young, sparse, or failed plantations, or non-forest plantation, is also difficult to detect. Even when land-use change is detected, the causal attribution of this change to sustainability policy investment, rather than other environmental and human drivers, is challenging. In addition, our results indicate that multiple sustainability interventions (e.g. mountain closure, logging bans, grazing bans, reforestation etc.) were implemented under multiple programs over time in each province. Disaggregating these impacts to specific programs or actions requires the application of sophisticated causal inference methodologies.

Although there are clear shortcomings with the statistical data used in our study, it provides the most comprehensive account of China's sustainability programs available. Even if the area statistics are exaggerated, the portfolio remains by far the largest sustainability intervention ever undertaken and the conclusions of this paper remain unchanged. Improvement of monitoring and evaluation processes and independent verification via remote sensing and causal inference studies can increase confidence in official statistics.

Supplementary Discussion

Past challenges with program implementation

Many challenges have arisen in program implementation, which have compromised sustainability outcomes. These challenges have been well-documented, especially for the Grain for Green and Natural Forest Conservation Programs¹⁰. They result from top-down administration, poor inter-agency cooperation and long-term planning, and inappropriate technical practices and institutional arrangements^{2,22}. Other impairments have included wastage and corruption, competition for program funds at multiple administrative levels with conflicting sustainability objectives¹⁵², focusing on outcomes rather than addressing the underlying interdependent social and ecological causes¹⁵³, restricted participant choice and local autonomy¹⁵⁴, and undifferentiated targeting of environments¹⁵⁵ and households¹⁵⁶. However, these maladies have typically been program-and context-specific, rather than systemic and widespread, and are unsurprising given the scale and complexity of the sustainability challenge. Suggested remedies have included systematic planning; diversified funding; effective compensation; integrated research; comprehensive and independent monitoring⁸; improved planning and management practices; stronger program governance; local engagement; effectiveness/impact assessment¹¹; more precise targeting¹⁵⁷; and more extensive piloting and experimentation¹⁵⁸.

Supplementary Table 1.

Program details for the Shelterbelt Development Program – Three North.

Program 1	The Three-North Shelterbelt Development Program (三北防护林体系建设工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	<p>The three regions of Northwest China, North China, and Northeast China, once lush agricultural and pastoral areas, are now desertified and dominated by drought; and wind erosion of sand and soil is limiting the region's economic development. In order to halt the desertification and improve the environment, the Chinese government established this program as an important national environmental and economic construction program in 1978. Specifically, over the life of the program, the aims are to¹⁵⁹:</p> <ul style="list-style-type: none"> Plant 35.08 million ha of forest, including 26.37 million ha of artificial plantation, 1.11 million ha of aerial seeding, and 7.60 million ha of mountain closure and sandy area regeneration. Plant 5.24 billion trees along the sides of roads, ditches, canals, and adjacent to houses. Increase forest cover from 5.05% in 1977 to 14.95% in 2050. Increase forest timber stock volume from 0.72 billion m³ in 1977 to 4.27 billion m³ in 2050. Rebuild forest networks across farmland in plains and oases. Effectively control the expansion of sandy and desertified land. Effectively control sandstorms and soil erosion. <p>Phase aims:</p> <ul style="list-style-type: none"> 1st Phase: Total construction area of 5.93 million ha, all for artificial plantation¹⁶⁰. 2nd Phase: Total construction area of 8.08 million ha, including 6.37 of artificial plantation, 1.54 million ha of mountain closure and 0.17 for aerial seeding¹⁶¹. 3rd Phase: Total construction area of 4.01 million ha, including 2.56 for artificial plantation, 1.16 million ha for mountain closure and 0.29 for aerial seeding¹⁶². 4th Phase: Total construction area of 9.50 million ha, including 6.30 for artificial plantation, 1.94 million ha for mountain closure and 1.26 for aerial seeding. Forest cover rate increased from 8.63% in 2000 to 10.47% in 2010¹⁶³. 5th Phase: Total construction area of 16.47 million ha, including 7.69 for artificial plantation, 7.82 million ha for mountain closure and 0.96 for aerial seeding. Forest cover rate will increase to 12.74% in 2020¹⁶⁴. 6th–8th Phases: Not yet defined.
Time frames	<p>3 Stages and 8 Phases 1978–2050:</p> <ul style="list-style-type: none"> 1st Stage 1978–2000: 1st Phase 1978–1985; 2nd Phase 1986–1995; 3rd Phase 1996–2000. 2nd Stage 2001–2020: 4th Phase 2001–2010; 5th Phase 2011–2020. 3rd Stage 2021–2050: 6th Phase 2021–2030; 7th Phase 2031–2040; 8th Phase 2041–2050.
Planned investment	<p>Total planned investment: 57.68 billion yuan^{165,166}:</p> <ul style="list-style-type: none"> 1st Phase: 1.0 billion yuan. 2nd Phase: 2.43 billion yuan¹⁶⁷. 3rd Phase: 4.82 billion yuan¹⁶⁸. 4th Phase: 35.41 billion yuan¹⁶³. 5th–8th Phases: Not yet defined.
Geography	<p>13 provinces targeted including Beijing, Hebei, Tianjin, Shanxi, Shaanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Gansu, Ningxia, Qinghai, and Xinjiang⁵¹.</p> <p>Key construction zones were established in serious sandstorm and soil erosion areas and natural disaster areas, mainly concentrating on controlling desertification in Horqin Sandy, Mu Us Sandy, Hulunbeier Sandy, Xinjiang and Hexi Corridor areas, and soil erosion control in the Yellow, Liaohe, Songhua, Nen, Shiyang, and Tarim River Basins¹⁶⁹.</p>
Implementation mechanisms	<p>4th Phase. Payments from central to local government¹⁶³:</p> <ul style="list-style-type: none"> 3,000 yuan ha⁻¹ for artificial plantation. 1,800 yuan ha⁻¹ for aerial seeding. 1,050 yuan ha⁻¹ for mountain closure. 97.5 yuan ha⁻¹ for management of national public welfare forest. 60,000 yuan ha⁻¹ for newly-building seed collection base, 20,000 yuan ha⁻¹ for rebuilding seed base. 4,000 yuan ha⁻¹ for newly-established seed collection base, 3,000 yuan ha⁻¹ for rebuilding seed collection base 60,000 yuan ha⁻¹ for newly-established high-quality plant breeding base and nursery, 20,000 yuan ha⁻¹ for rebuilding high-quality plant breeding base and nursery. <p>5th Phase. Payments from central to local government¹⁶⁹:</p>

	<ul style="list-style-type: none"> • 7,500 yuan ha⁻¹ for artificial plantation. • 1,800 yuan ha⁻¹ for aerial seeding. • 1,500 yuan ha⁻¹ for mountain closure.
Performance to-date	<p>At the end of 2015, \$8.34 billion (2015 USD) had been invested by the central and local governments. An area of 42.88 million ha had been addressed including a forest plantation area of 37.22 million ha^{170,171}. Phase performance (not including inefficient forest transformation)^{163,168}:</p> <ul style="list-style-type: none"> • 1st Phase: Addressed 5.34 million ha, including 4.59 of artificial plantation, 0.71 million ha of mountain closure and 0.04 of aerial seeding • 2nd Phase: Addressed 10.78 million ha, including 7.27 of artificial plantation, 3.05 million ha for mountain closure and 0.46 of aerial seeding • 3rd Phase: Addressed 5.91 million ha, including 3.53 of artificial plantation, 1.99 million ha for mountain closure and 0.39 of aerial seeding • 4th Phase: Addressed 4.43 million ha, including 3.23 of artificial plantation, 1.19 million ha for mountain closure and 0.01 of aerial seeding. • 5th Phase: Addressed 1.94 million ha, including 1.12 of artificial plantation, 0.81 million ha of mountain closure and 0.01 of aerial seeding
Unintended consequence	Large-scale plantations in this program have lowered groundwater tables and intensified water stress at regional scales ¹⁷² . Thus, the target achievement of this program (combating desertification) is uncertain with altered climate in the longer term.
Monitoring	First, contracted tasks are examined and accepted by local government after completion. Then, participants need to apply for formal acceptance to the Shelterbelt Construction Bureau in the Northwest, North, or Northeast State Forestry Administrations.
Level of community engagement	At the end of 2012, about 170 million people had been involved in this program ⁵¹ crossing 13 provinces and 600 counties.

Supplementary Table 2.

Program details for the Soil and Water Conservation Program – National.

Program 2	National Key Construction Program for Soil and Water (国家水土保持重点建设工程)
Governing agencies	Ministry of Water Resources.
Aims/Objectives	This program aims to control soil erosion, and to improve agricultural production conditions, ecology, and the environment. It employs methods of artificial prevention and control, and ecological regeneration to promote the adjustment of rural industrial structure and sustainable regional socio-economic development.
Time frames	1 st Phase: 1983–1992. 2 nd Phase: 1993–2002. 3 rd Phase: 2003–2007. 4 th Phase: 2008–2012. 5 th Phase: 2013–2017.
Planned investment	1 st Phase: total investment of 300 million yuan, or 30 million yuan yr ⁻¹ . 2 nd Phase: 450 million yuan. 1993–1997 200 million yuan or 40 million yuan yr ⁻¹ ; 1998–2002 250 million yuan or 50 million yuan yr ⁻¹ . 3 rd Phase: 280 million yuan. 2003–2006 200 million yuan or 50 million yuan yr ⁻¹ , and 2007: 80 million yuan ¹⁷³ . 4 th Phase: 3.01 billion yuan ^{173,174} . 5 th Phase: total investment of 10.5 billion yuan with a central government contribution of 7.35 billion yuan ¹⁷⁵ .
Geography	The priority areas of this program are those with severe soil erosion and are in the list of key areas in the “National ecological environment construction plans for soil and water conservation” ¹⁷⁶ . It is implemented in 5 Phases: <ul style="list-style-type: none"> 1st Phase: 9 provinces - Beijing, Hebei, Shanxi, Inner Mongolia, Hubei, Liaoning, Jiangxi, Shaanxi, and Gansu. 2nd Phase: 8 provinces - Beijing, Hebei, Shaanxi, Inner Mongolia, Liaoning, Jiangxi, Shanxi, and Gansu. 3rd Phase: 8 provinces - same as the 2nd Phase. 4th Phase: 12 provinces - Beijing, Hebei, Shanxi, Inner Mongolia, Liaoning, Fujian, Jiangxi, Shandong, Anhui, Henan, Shaanxi, and Gansu. 5th Phase: 20 provinces - Beijing, Hebei, Shanxi, Inner Mongolia, Liaoning, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Shaanxi, Gansu, and Ningxia . This Phase's construction covers 279 counties in 20 provinces, distributed in 12 old revolutionary base areas, such as the Taihang, Dabie, and Yimeng Mountains. A total number of more than 2,800 small watersheds will be comprehensively managed and the total management area will amount to 30,000 km².
Implementation mechanisms	The construction should focus on building new countryside and actively explore ecologically clean, economic, and secure small watershed management models. This program regards a small watershed as a management unit and comprehensively manages lands, water, mountains, roads, and villages. The program starts with improving livelihoods and increase farmers' income via actions for controlling soil and water loss and improving the ecology and environment ¹⁷⁶ . <ul style="list-style-type: none"> Prioritize areas with lower socio-economic development and serious soil and water loss issues in Types 1 and 2 old revolutionary base areas. Combine soil erosion management and economic development, especially develop local industry and realize “win-win” situations between ecological construction and economic development. Control soil erosion by combining prevention, protection, supervision, control, and repair via utilizing appropriate scientific, engineering, plantation, and cultivation measures. Adopt the mechanism of “government-guiding and society-participating”. The program is implemented in different regions as follows ¹⁷⁵ : <ul style="list-style-type: none"> Northwestern loess plateau region: sloping farmland management and channel erosion control is the top priority, support the construction of rainwater collection and water-saving irrigation projects, promote rain-fed agriculture technology, and develop distinctive horticulture and livestock industries. Northern mountainous region: the conversion of sloping farmland is the top priority, focus on the construction of forest and grass vegetation, promote rainwater utilization technology, vigorously construct bases of high-quality fruit products, achieve food self-sufficiency, and increase farmers' income. Northeastern black soil region: the protection of black soil resources and the safeguard of national food security is the top priority, highlight the management of sloping farmland, manage gully erosion, effectively control soil erosion, and promote the production of high-quality, high-yield and efficient commodity grain. Southern rocky mountain region: the scientific utilization of land and water resources and increasing the environmental capacity of population is the top priority, regulate sloping farmland, build slope drainage projects, establish economic orchard industries, strengthen ecological restoration, and promote the virtuous circle of the ecological economy. Southern red soil region: the management of soil and water loss in hilly land is the top priority, construct high-yield and stable-yield farmland, make full use of heat and water resources and plant resources,

	develop high-quality and efficient horticulture, restore and improve vegetation coverage, and lift farmers out of poverty.
Performance to-date	<p>As of 2015, the total investment under this program was \$1.73 billion (2015 USD) and the total treated area was 7.63 million ha.</p> <p>Since this program started in 1983, more than 3,800 small watersheds have been comprehensively treated and the total treated area amounts to 5.83 million ha (2012), including converting cultivated slope lands into forest and grassland over more than 0.667 million ha^{174,175}.</p> <p>The four Phases of the program have made remarkable achievements^{174,177}:</p> <ul style="list-style-type: none"> Effectively improved the ecology and environment in the program management areas. Vegetation coverage has increased by 24% on average. Water and soil erosion has been effectively controlled in program areas. Sediment reductions above 40% have been achieved in managed small watersheds and the sediment that flows into the rivers and lakes has been significantly reduced. Estimated sediment reduction capacity has reached more than 420 million tonnes per year. <p>The program has effectively promoted local economics and social development¹⁷⁴:</p> <ul style="list-style-type: none"> More than 810,000 ha basic farmland has been constructed. More than 300,000 small-scale water conservation projects have been built. More than 810,000 ha of economic orchards have been planted. Farmer's income per capita has increased by 400 yuan yr⁻¹. More than 10 million farmers have been lifted from poverty. <p>Performance indicators of Phase 5 include:</p> <ul style="list-style-type: none"> Management of soil erosion in the program areas will increase to more than 70%. Forest or grass coverage rate will increase to above 50%. Construction area of basic farmland will reach 130,900 ha. Construction area of economic orchard will be 241,600 ha. Farmers' income per capita will further increase by 300–500 yuan yr⁻¹. 13 million poor people are expected to be out of poverty.
Unintended consequences	The wide scope of conservation, massive management objectives, and high degree of local variation may lead to that management measures are not sufficiently adapted or suited to local conditions. The program lacks systematic and comprehensive governance ^{178,179} .
Monitoring	This program uses supervised monitoring, where a supervision company is responsible for monitoring and managing the construction works. The supervision company should be qualified for ecological supervision work of soil and water conservation, and selected by the county-level department of water resources via bidding for contracts. The supervision company should independently carry out the monitoring and management work in terms of the contract ¹⁷⁶ . Opportunities for local people to engage with the program are proclaimed prior to implementation. Before the implementation of the program, the construction proposal, subsidy content, expected benefits, and required efforts from the people should be made clear and transparent to the people in program regions ¹⁷⁶ .
Level of community engagement	The program adopts hierarchical management from the State, Province, Prefecture (city), and County, involving 279 counties in 20 provinces. By 2013, more than 1 billion working days had been invested by local people, and more than 10 million people have been pulled out of poverty ¹⁷⁴ .

Supplementary Table 3.

Program details for the Shelterbelt Development Program – Five Regions.

Program 3	The Shelterbelt Development Program in Five Regions including the Middle and Lower Reaches of the Yangtze River (长江中下游地区等防护林体系建设工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	<p>In order to arrest the deterioration of the ecology and environment of the Yangtze River, Pearl River, and their coastal areas, 5 programs including the Yangtze River Shelterbelt, Coastal Shelterbelt, Pearl River Shelterbelt, Taihang Mountain Greening, and the Plain Greening were launched in 1989, 1990, 1996, 1994 and 1987, respectively. From 2001, these five programs were combined into the Shelterbelt Development Program – Five Regions and re-planned for the second Phase^{180,181}.</p> <p>2nd Phase aims include¹⁸²:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 6.88 million ha of forest plantation, including 3.13 million ha of artificial plantation, 3.48 million ha of mountain closure, and 0.27 million ha of aerial seeding; and 3.88 million ha of improving low-yielding forest. Pearl River Shelterbelt: 2.28 million ha of forest plantation, including 0.88 million ha of artificial plantation, 1.37 million ha of mountain closure, and 0.03 million ha of aerial seeding; and 1.00 million ha of improving low-yielding forest. Coastal Shelterbelt: 1.36 million ha of forest plantation, including 0.68 million ha of artificial plantation, 0.61 million ha of mountain closure, and 0.07 million ha of aerial seeding; and 0.98 million ha of improving low-yielding forest. Taihang Mountain Greening: 1.46 million ha of forest plantation, including 0.67 million ha of artificial plantation, 0.51 million ha of mountain closure, and 0.28 million ha of aerial seeding; and 0.45 million ha of improving low-yielding forest. The Plain Greening: 5.52 million ha, including 0.42 million ha of farmland shelterbelts, 2.94 million ha of barren hills greening, 1.13 million ha of village greening, and 0.30 million ha of garden township; and 0.73 million ha of improving farmland shelterbelts. <p>3rd Phase aims to significantly improve the environmental and ecological conditions in the implementation regions. Specific aims include:</p> <ul style="list-style-type: none"> 21.67 million ha of forest plantation, increasing the forest cover rate of these regions by 4.1%¹⁸³. Yangtze River Shelterbelt: 12.78 million ha of forest plantation, including 3.62 million ha of artificial plantation, 9.07 million ha of mountain closure, and 0.09 million ha of aerial seeding¹⁸⁴. Pearl River Shelterbelt: increase forest area by 1.53 million ha and increase forest cover by 60.48%¹⁸⁵. Taihang Mountain Greening: 1.68 million ha of forest plantation, including 0.82 million ha of artificial plantation, 0.50 million ha of mountain closure, and 0.04 million ha of aerial seeding, restore 0.32 million ha of degraded forest. Increase forest area by 0.80 million ha and forest cover rate by 9.7%¹⁸⁶. The Plain Greening: 7.06 million ha of forest plantation, including 4.92 million ha of artificial plantation, 1.28 million ha of improving farmland shelterbelts, and 0.86 million ha of agroforestry¹⁸⁷.
Time frames	<p>1st Phase: 1987–2000.</p> <p>2nd Phase: 2001–2010.</p> <p>3rd Phase: 2011–2020.</p>
Planned investment	<p>1st Phase: 10.94 billion yuan (not including The Plain Greening)¹⁸⁸.</p> <p>2nd Phase: 34.61 billion yuan¹⁸¹.</p> <p>3rd Phase: 212.87 billion yuan¹⁸³.</p>
Geography	<p>Yangtze River Shelterbelt: 17 provinces namely Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Chongqing, Sichuan, Yunnan, Guizhou, Shaanxi, Gansu, Qinghai, and Tibet¹⁸⁴. Focus on the construction of shelterbelts, water and soil conservation forest in Dongting Lake, Poyang Lake, and Danjiangkou Reservoir¹⁸⁴.</p> <p>Pearl River Shelterbelt: 6 provinces namely Guangxi, Guangdong, Yunnan, Guizhou, Hunan, and Jiangxi. Focus on the construction of water and soil conservation forest in north Pan River and south Pan River, Northeast River, Zuo River and You River, Red River, and the middle and lower reaches of Pearl River¹⁸⁵.</p> <p>Taihang Mountain Greening: 4 provinces namely Beijing, Hebei, Shanxi, and Henan. Focus on the key area of soil erosion in the 7 rivers of Sanggan River, Daqing River, Hutuo River, Fuyang River, Zhang River, Wei River and Qin River¹⁸⁶.</p> <p>The Plain Greening: 26 provinces namely Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang. Focus on the 404 grain-producing counties¹⁸⁷.</p>
Implementation mechanisms	<p>3rd Phase. Direct payments to landholders for undertaking restoration actions:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 9,750 yuan ha⁻¹ for artificial plantation (including all costs of seedlings, site preparation, planting, replanting, the tending and managing after 3 years' planting), 1,050 yuan ha⁻¹ for

	<p>mountain closure (including all the fees of fencing, billboards, replanting, and 5–8 years of forest management), 1,800 yuan ha⁻¹ for aerial seeding (including seed treatment, ground handling, and management after aerial seeding), and 7,500 yuan ha⁻¹ for low-yielding forest¹⁸⁴.</p> <ul style="list-style-type: none"> The Plain Greening: 7,500 yuan ha⁻¹ for establishment of shelterbelts, forest plantation on suitable land, and greening township; 3,000 yuan ha⁻¹ for restoration of shelterbelts; 1,500 yuan ha⁻¹ for agroforestry¹⁸⁷.
Performance to-date	<p>At the end of 2015, \$8.48 billion (2015 USD) had been invested by the central and local governments.</p> <p>1st Phase: \$1.4 billion (2015 USD) not including the Plain greening¹⁸⁸.</p> <p>2nd Phase: \$3.02 billion (2015 USD).</p> <p>3rd Phase: \$4.06 billion (2015 USD) by the end of 2015.</p> <p>At the end of 2015, the implementation area was 21.43 million ha, the total area of forest plantation was 15.51 million ha^{170,171}, where 7.91 million ha was established between 1989–1997 and 7.60 million ha between 1998–2015. Forest cover rate was increased 4.7, 12.2, 7.7 and 1.3% in the Yangtze River, Pearl River, Taihang Mountain Greening, and Plain Greening regions, respectively¹⁸³.</p> <p>1st Phase¹⁸⁹:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 6.86 million ha of forest plantation, including 4.23 million ha of artificial plantation, 2.21 million ha of mountain closure, and 0.08 million ha of aerial seeding; and 0.35 million ha of tending young forest Pearl River Shelterbelt: 0.67 million ha of forest plantation, including 0.23 million ha of artificial plantation 0.28 million ha of mountain closure, and 0.03 million ha of aerial seeding; and 0.13 million ha of improving low-yielding forest. Coastal Shelterbelt: 3.24 million ha of forest plantation, including 2.46 million ha of artificial plantation, 0.72 million ha of mountain closure, and 0.05 million ha of aerial seeding. Forest cover increased by 10.55% in the program area. Taihang Mountain Greening: 2.95 million ha of forest plantation, including 1.65 million ha of artificial plantation, 1.00 million ha of mountain closure, and 0.03 million ha of aerial seeding. Forest cover increased by 6.28% in the program area. The Plain Greening: Forest cover was increased by 8.4% in the program area. Established 3.77 million ha of new farmland shelterbelts. <p>2nd Phase:</p> <ul style="list-style-type: none"> Pearl River Shelterbelt: 1.21 million ha of forest plantation, and 1.06 million ha of low-yielding forest improvement. Forest cover increased by 7.5%¹⁹⁰. The Plain Greening: Forest plantation of 6.74 million ha and forest cover increased by 2.6% in the program area, including 3.04 million ha of forest planting on suitable land; establishment of 1.55 million km (about 1.41 million ha) of new farmland shelterbelts; restoration of 0.54 million km (about 0.50 million ha) of farmland shelterbelts; 0.74 million ha of agroforestry establishment; established 134,900 township gardens (about 0.17 million ha) and 128,500 village greening areas (about 0.74 million ha)¹⁸⁷. <p>3rd Phase</p> <ul style="list-style-type: none"> The implementation area was 2.55 million ha from 2011–2014 for all 5 shelterbelts and greenings, including 1.56 million ha of forest plantation, 0.03 million ha of inefficient forest transformation, and 0.96 million ha of mountain enclosure¹⁷¹.
Unintended consequences	Rehabilitated areas in this program are often destroyed by local people and long-term maintenance of the forest shelterbelt faces difficulties because government funding is neither sufficient nor stable. With inadequate economic incentives for participation, and local needs often ignored, the sustainability of restored areas is at risk ¹⁹¹ .
Monitoring	This program is subject to management by objectives. Local forestry departments set up a project management organization to organize the implementation of the construction, and established management responsibility system for plantation operations, construction supervision, technical services, and inspection and acceptance. Implementation of a target system for the local government, and the fulfilment of this objective is the responsibility of the local government leadership ¹⁸⁴ . Projects are self-examined by county governments, reviewed by municipal governments, and verified by the provincial or district governments.
Level of community engagement	<p>1st Phase:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 271 counties¹⁹². <p>2nd Phase¹⁸⁹:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 17 provinces 1035 counties. Pearl River Shelterbelt: 6 provinces 187 counties. Coastal Shelterbelt: 11 provinces 221 counties. Taihang Mountain Greening: 4 provinces 77 counties. The Plain Greening: 26 provinces 944 counties. <p>3rd Phase:</p> <ul style="list-style-type: none"> Yangtze River Shelterbelt: 17 provinces 1026 counties¹⁸⁴. Pearl River Shelterbelt: 6 provinces 186 counties¹⁸⁵. Taihang Mountain Greening: 4 provinces 78 counties¹⁸⁶. The Plain Greening: 24 provinces 923 counties¹⁸⁷.

Supplementary Table 4.

Program details for the Comprehensive Agricultural Development Program.

Program 4	Comprehensive Agricultural Development Program (农业综合开发工程)
Governing agencies	The Ministry of Finance, State Office for Comprehensive Agricultural Development, Provincial Office for Comprehensive Agricultural Development.
Aims/Objectives	<p>The aims of the program are to raise the quality of life in the countryside, and to expedite land reform and long-term food security. The State Council established the National Land Development and Construction Fund in 1988, which later became the special Comprehensive Agricultural Development Fund to support the program. The program includes 2 projects of land development and industrialization¹⁹³:</p> <ul style="list-style-type: none"> Improving land management. Mainly to strengthen the agricultural infrastructure and ecological construction, and improve comprehensive agricultural production capacity to ensure national food security. Developing agricultural industries. Aiming to construct agricultural processing, forestry, livestock, and aquaculture, improve the overall efficiency of agriculture and increase farmers' income. <p>Objectives:</p> <ul style="list-style-type: none"> 1st Phase: Improve low-yielding cropland and reclaim wasteland suitable for agriculture to ensure the stable growth of crop, cotton, oil, and other major agricultural products. 2nd Phase: Improve agricultural production capacity, develop aquaculture, and increase the quality and efficiency of economic crops to improve farming efficiency. 3rd Phase: First, improve the low-yielding cropland and reclaimed wasteland to improve agricultural production capacity and protecting the environment; second, adjust the structure to develop high-yielding and efficient agriculture relying on science and technology. 4th Phase: improving low and medium yield cropland and building a demonstration project of high-yielding cropland. Aims to construct 33.33 million ha of new, highly productive farmland from 2011–2020.
Time frames	<p>1st Phase: 1988–1993.</p> <p>2nd Phase: 1994–1998.</p> <p>3rd Phase: 1999–2010.</p> <p>4th Phase: 2011–2020⁵⁵.</p>
Planned investment	<p>1st Phase: 32.65 billion yuan.</p> <p>1994: 7.16 billion yuan.</p> <p>No information on planned investment for other years is available.</p>
Geography	<p>1988: 495 counties in 11 provinces including Hebei, Shandong, Henan, Jiangsu, Anhui, Heilongjiang, Jilin, Liaoning, Zhejiang, Xinjiang, Guangxi.</p> <p>796 counties in 1990, 1197 counties in 1995, 1559 counties in 2000, 1882 counties in 2005 and 1975 counties in 2010^{194,195}.</p>
Implementation mechanisms	<p>The program cycle is divided into four Stages: preliminary selection, project preparation, project implementation, and completion acceptance¹⁹⁶.</p> <p>For projects aimed at improving land management and developing agricultural industries, project selection is a bottom-up application and top-down screening process. First, the relevant counties need to prepare a project feasibility report and then the national and provincial agricultural development office should organize the assessment, to determine the support projects and incorporate it into the project plan. To ensure the quality of the project, the CAD program office at all levels should inspect and supervise the implementation of the project, carry out regular or special inspections, correct deficiencies^{196,197}. Projects aimed at developing agricultural industries can also follow the process of construction before subsidizing, which means that enterprises or individuals invest in projects first, and then apply for subsidies after completion and on-site inspection. The central financial subsidy funds are in the range of 1–2 million yuan for a leading enterprise project, and of 0.5 million to 1 million yuan for farmer cooperative project¹⁹⁸.</p>
Performance to-date	<p>Total investment under this program up to 2015 was \$142.06 billion (2015 USD)¹⁹⁴:</p> <ul style="list-style-type: none"> 1st Phase: \$15.92 billion (2015 USD) 2nd Phase: \$10.04 billion (2015 USD) 3rd Phase: \$62.10 billion (2015 USD) 4th Phase (2011–2015): \$54.00 billion (2015 USD) <p>The treatment area (of projects aimed at improving land management) was 55.97 million ha from 1988–2015, including improvement of low and medium yield cropland, demonstration project of high standard cropland, grassland development, small watershed improvement and land desertification control, of which, from 1988–2015 the addressed area as below¹⁹⁴:</p> <ul style="list-style-type: none"> 1st Phase: 10.37 million ha. Improved 9.57 million ha of low and medium-yield cropland, developed 0.80 million ha of grassland. 2nd Phase: 8.73 million ha. Improved 7.90 million ha of low and medium-yield cropland, developed 0.83 million ha of grassland.

	<ul style="list-style-type: none"> 3rd Phase: 25.88 million ha. Improved 22.64 million ha of low and medium-yield cropland, developed 2.28 million ha of grassland, 0.35 million ha of demonstration projects of high-standard cropland, undertook 0.44 million ha of small-watershed improvement, and 0.17 million ha of land desertification control. 4th Phase (2011–2015): 10.99 million ha. Improved 3.43 million ha of low and medium-yield cropland, built 5.89 million ha of demonstration projects of high-yielding cropland; developed 1 million ha of grassland, undertook 0.57 million ha of small-watershed improvement and 0.1 million ha land desertification control. <p>Increased productivity of major agricultural products during 1988–2014¹⁹⁴:</p> <ul style="list-style-type: none"> Grain 108.14 million tonnes, cotton 1.98 million tonnes, oil crops 5.27 million tonnes, and sugar crops 29.71 million tonnes. <p>Increased output value of other agricultural products during 1988–2010:</p> <ul style="list-style-type: none"> Livestock products 65.93 billion yuan and aquacultural products 9.65 billion yuan.
Unintended consequences	<p>It has been suggested that the policy efforts have not been efficient at reducing land fragmentation in this program¹⁹⁹. Current land fragmentation is proven to improve farmers' income²⁰⁰; therefore, doing land consolidation to reduce fragmented lands without compensating farmers unavoidably reduces economic returns to farmers and it is more difficult for them to be successful.</p>
Monitoring	<p>Projects under this program must be inspected after completion, involving:</p> <ul style="list-style-type: none"> Self-inspection. Provincial inspection, which is carried out by the departments of the State Council. National inspection, which is a sample testing carried out on the basis of provincial inspection. <p>If a project is accepted, the National Agricultural Comprehensive Development Office will issue certificates. If not, correction should be made within a fixed period. If it fails to meet the requirements within the given period, the Ministry of Finance may decline to arrange additional funds, reduce the existing investment, suspend the investment, cancel the project, or even disqualify the country from accessing further funding^{196,201,202}.</p>
Level of community engagement	<p>From 1998–2014, 1.236 million people underwent technical training. At the end of 2014, 2,123 counties and 234 farms (animal husbandry, forestry) were supported by the program⁵⁵.</p>

Supplementary Table 5.

Program details for the Soil and Water Conservation Program – Yangtze.

Program 5	Program of Soil and Water Conservation in Key Areas of the Upper Yangtze River (长江上中游水土保持重点防治工程)
Governing agencies	Ministry of Water Resources.
Aims/Objectives	The Yangtze River basin is characterized by high mountains, steep slopes, high rainfall, highly erodible rock and soil substrate, and high population density. With its intense human activity and long-term unsustainable land development, soil erosion is very serious. The soil erosion area of the whole basin is 622,000 km ² , mainly (88%) occurring in the middle and upper reaches. The upper and middle reaches of the Yangtze River have experienced some of the most severe soil erosion in China ²⁰³ . The aims of this program are to reduce sedimentation of the Yangtze River and ensure the safe operation of the Three Gorges reservoir by promoting erosion control in the upper reaches of the Yangtze River, improving the ecological environment of the Yangtze River, and enhancing regional economic and social development ^{203,204} .
Time frames	From 1989, indefinite.
Planned investment	Investment varies year-to-year depending on the size and quality of the proposals submitted for funding: <ul style="list-style-type: none">• Before December 31st of each year, relevant counties declare their interest to the provincial water and soil conservation authorities for the next year's governance tasks and investment plans.• Provincial department submits the governance tasks and investment plans to the Yangtze River Commission according to the annual inspection and assessment of the relevant county before March 31st.• Yangtze River Commission assesses the governance tasks and investment plan according to the annual provincial target assessment, and reports to the Ministry of Water Resources for approval.• The Annual investment is determined according to the area of approved project and investment standards of that year²⁰⁵.
Geography	From 1989, the program was implemented in four areas: the lower reaches of the Jinsha River and Bijie area; the lower reaches of the Jialing River; the southern areas of Shanxi and Gansu provinces; and the Three Gorges Reservoir area ⁵² . After 1994, with a focus on prevention and treatment, the area was gradually extended to the middle of the Danjiangkou Reservoir, the river systems of Dongting Lake, Poyang Lake, and the south of Dabie Mountain, spanning 9 provinces (Yunnan, Guizhou, Sichuan, Gansu, Shaanxi, Chongqing, Henan, Hunan, and Jiangxi) ²⁰⁶ . To 2008, the program had been continuously implemented in 7 Phase projects, covering the upper and middle reaches of Yangtze River including 10 provinces (Yunnan, Guizhou, Sichuan, Gansu, Shaanxi, Chongqing, Hubei, Henan, Hunan, Jiangxi) and 214 counties (cities, districts). The program has also led to the comprehensive management up to 5,445 small watersheds ⁵² .
Implementation mechanisms	For this program, the small watershed is recognised as a basic unit, and the period of implementation is 4–5 years ²⁰⁶ . Early in the program, the state invested 9,000 yuan km ⁻² , and gradually increased this to 15,000 yuan km ⁻² , 30,000 yuan km ⁻² , 60,000 yuan km ⁻² , and 100,000 yuan km ⁻² by 2008 ²⁰⁷ . Project procedure ²⁰⁵ : <ul style="list-style-type: none">• The Yangtze River Commission proposes principles and requirements of the layout of the project, the provincial soil and water conservation authorities determine the project area; and the project area is a region with geographically continuous area > 100 km² of soil erosion.• The provincial soil and water conservation authorities organize the preparation of the project feasibility report, and supporting funds are committed to the Yangtze River Commission.• The Yangtze River Commission does the review and approval on the provincial feasibility report.• The county of the project site prepares the preliminary design of the project on the basis of the feasibility report and in accordance with the relevant requirements, and reports to higher authorities.• The preliminary design of the project will be reviewed by the provincial soil and water conservation authorities, and reported to the Yangtze River Commission for record. After the preliminary design is approved, the project can be started.
Performance to-date	As of 2015 the total investment under the program was \$1.59 billion (2015 USD) covering a total treated area of 12.93 million ha. Specific program impacts include the following: <ul style="list-style-type: none">• Area of soil erosion decreased⁵². As of 2008, after 20 years of governance, the most serious “four areas” of soil erosion decreased by 40–60%, sloping farmland was reduced by nearly 80%, and soil erosion rates in small watersheds were reduced by more than 70%. According to a remote sensing survey the area of soil erosion in the vicinity of the Three Gorges Reservoir declined at an average annual rate of 1%, reducing by 19% overall. The area of soil erosion in the Jialing River Basin decreased from 58% to 39%.• Water and soil conservation capacity was enhanced⁵². Through the integrated configuration of control measures, water storage capability of productive land and ecological land has been significantly enhanced by retaining and reducing surface runoff, and increasing soil water infiltration. This has not only reduced the

	<p>harm to downstream farmland, reservoirs, and ponds, but also avoids soil degradation caused by nutrient loss.</p> <ul style="list-style-type: none"> Ecology and environment have improved significantly⁵². As of 2008, the program created a total of 2.41 million ha of water conservation forest, 330,000 ha of grassland, and closed 3.35 million ha area for reforestation. Forest area increased by 40% and forest coverage rate increased by 30%. According to the survey including 22 typical counties, the area of barren hills decreased by two thirds, forest area increased by 31%, and forest coverage rate increased from 38% to the current 49%. Through the transformation of land, and plantation of forest and fruit trees, access to food and clothing was enhanced for more than 10 million farmers^{52,206}.
Unintended consequences	The scope of this program includes poor areas where part of the population is still in poverty. Focusing on ecological and social benefits while ignoring the development of the rural economy and growth of farmers' income has restricted the program implementation in these areas ^{208,209} .
Monitoring	<p>The relevant department of soil and water conservation in the county is responsible for construction in the program. Contract management is adopted in the project. The relevant department should choose the construction unit, determine the content of the construction, and to sign the construction contract.</p> <p>The program uses a supervision system to control the quality of construction, progress, and investment. The place where there is no implementation of a supervision system, the relevant department should provide technical guidance and supervision, send site personnel, and take the responsibility of ensuring the project is implemented according to design²⁰⁵.</p> <p>After completion of one project, the relevant county undertakes self-appraisal and applies for acceptance to the program. After inspection by the provincial soil conservation department, the Yangtze River Commission completes the acceptance. Finally, the Yangtze River Water Conservancy Commission issues a certificate of acceptance. If the application is not accepted, the relevant county's projects for next year will be reduced or suspended. If the issues cannot be rectified, the project will no longer qualify for funding²⁰⁵.</p>
Level of community engagement	The <i>four area</i> supports a population of 65.34 million people, with an agricultural population of 59.35 million ⁵² . More than 10 million farmers now have better access to food and clothing because of the program ^{52,206} . The program has mobilized more than 2.1 billion working days of labour towards conservation actions ^{52,207} .

Supplementary Table 6.

Program details for the National Land Consolidation Program.

Program 6	National Land Consolidation Program (国家土地整治工程)
Governing agencies	The Ministry of Land and Resources.
Aims/Objectives	In order to manage the area of cultivated land, improve its utilization, and increase land revenues, the Ministry of Land and Resources founded the Land Consolidation and Rehabilitation Center in 1998 to oversee the National Land Development and Consolidation Program and formulate a series of relevant policies with the following aims: 1 st Phase: <ul style="list-style-type: none"> • Increase the area of cultivated land by 2.74 million ha, including 1.66 million ha of land consolidation (i.e. reorganise and merge fragmented and underused land) through farmland and rural residential areas, 0.35 million ha through reclamation of abandoned industrial and mining land, and 0.73 million ha via land development²¹⁰. 2 nd Phase: <ul style="list-style-type: none"> • Construct 26.67 million ha of high-quality cropland. • Increase the area of cultivated land by 1.60 million ha, including 0.72 million ha of land consolidation through farmland and rural residential areas, 0.283 million ha through land reclamation of abandoned industrial and mining land, and 0.597 million ha via land development²¹¹. • Consolidate 0.3 million ha of rural construction land.
Time frames	Pilot Phase: 1997–2000. 1 st Phase: 2001–2010. 2 nd Phase: 2011–2020.
Planned investment	1st Phase: 333 billion yuan, including 261 billion yuan for land consolidation, 43 billion yuan for land reclamation, and 29 billion yuan for land development ²¹⁰ . 2nd Phase: <ul style="list-style-type: none"> • 2011–2015: 600 billion yuan²¹¹. • 2016–2020: 1.7 trillion yuan²¹².
Geography	The program covers the whole country, with specific target areas as follows: 1 st Phase ²¹⁰ : <ul style="list-style-type: none"> • Land consolidation: mainly in 10 regions of 1,180 counties including North China Plain, the Yangtze River Plain, Northeast Plain, South China hilly plain, Zhejiang and Fujian hilly plain, the Yunnan-Guizhou Plateau, the Loess Plateau, Sichuan Basin and the Qinba Mountain, Inner Mongolia Plateau, and the Tianshan piedmont oasis region. • Land development: mainly in 6 regions of 115 counties including eastern coastal beach area, the Hetao region of Yinchuan Plain, the middle part of Yunnan, Shule River basin and the Yellow River Irrigation District, Yili River Valley and southern and northern foothills oasis region in Xinjiang, and south-west Sichuan. • Land reclamation: mainly in 10 regions of 325 counties including the coal, iron, and steel base in the eastern part of Hebei; coal, iron, steel and non-ferrous metal base in Heilongjiang, Jilin and Liaoning; coal, iron, and steel base in the southern parts of Hubei and Shanxi and the northern part of Henan; coal and chemical industry base in Shanxi, Shaanxi, and Inner Mongolia; iron, steel, and non-ferrous metal base in Jiangsu, Shandong and Anhui; coal base in the middle of Henan; non-ferrous metal, iron, steel, and coal base in Hubei, Jiangxi and Fujian; chemical industry and coal base in Hunan and Guangdong; non-ferrous metal, building materials, and coal base in Guangxi; non-ferrous metal, iron, steel, and chemical industry base in Sichuan, Yunnan, and Guizhou. 2 nd Phase ²¹¹ : <ul style="list-style-type: none"> • Farmland consolidation: Same 10 regions as addressed during 2001–2010, but covering 1,618 counties. • Basic farmland consolidation: Mainly targeting 16 provinces (875 counties), among which 13 provinces are major grain-producing areas (Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Hebei, Henan, Jiangsu, Anhui, Hubei, Hunan, Jiangxi, Sichuan, Shaanxi, and Hainan). • Land development: mainly targeting 9 regions (225 counties) including the eastern coastal beach area, the Hetao region of Yinchuan Plain, south-west Yunnan, south-west Sichuan, west Jilin, Sanjiang Plain, the foothills oasis region of southern and northern Xinjiang, the central Hexi Corridor along the Yellow River irrigation area, and the Qinghai-Tibet region. • Land reclamation: mainly in the same 10 regions as for 2001–2010 but covering 474 counties.
Implementation mechanisms	Leading agencies have been established by the government at all levels to organize and implement the program ²¹³ . Government provides guidance and targeting of on-ground action, while implementation occurs at all levels of the Land and Resources Bureau, with cooperation among sectors, and encouraging public participation in the work ²¹³ .

	A system has been established to evaluate the local government's performance in administering and implementing the program ²¹³ . 1 st Phase: Payment rates were 157,500 yuan ha ⁻¹ for land consolidation, 122,700 yuan ha ⁻¹ for land reclamation, and 39,750 yuan ha ⁻¹ for land development ²¹⁰ .
Performance to-date	Total investment under this program up to 2015 was 76.17 billion ²¹⁴ : <ul style="list-style-type: none"> • Pilot Phase: US\$ 3.17 billion (2015 USD). • 1st Phase: US\$ 33.97 billion (2015 USD). • 2nd Phase 2011–2015: US\$ 39.03 billion (2015 USD). The total treatment area up to 2015 was 16.65 million ha ²¹⁴ : <ul style="list-style-type: none"> • Pilot Phase: total implementation area was 0.83 million ha, including land consolidation 0.18 million ha, land development 0.52 million ha and land reclamation 0.13 million ha. • 1st Phase: total implementation area was 7.07 million ha, including land consolidation 3.1 million ha, land development 1.65 million ha and land reclamation 2.32 million ha. • 2nd Phase 2011–2015: total implementation area was 8.75 million ha. By the end of 2014 the treatment area was 6.9 million ha, including land consolidation 5.85 million ha, land development 0.9 million ha and land reclamation 0.15 million ha.
Unintended consequences	This program has decreased ecosystem service value in places (due to ecosystem service loss of wetlands and grasslands) and changed the ecological connectivity as well as the land-use structure in some regions ²¹⁵ . Land consolidation has not been a panacea for solving the rural land-use issues in China's <i>building a new countryside strategy</i> ²¹⁶ .
Monitoring	1 st step: Project application by local government. 2 nd step: the Ministry of Land and Resources takes charge of the project checking ²¹⁷ . 3 rd step: Completion acceptance test of the project: Self-examination, primary inspection, and final inspection ²¹⁸ .
Level of community engagement	1 st Phase: 1,720 counties, government, and Land and Resources Bureau. 2 nd Phase 2011–2015: 3,192 counties, government, and Land and Resources Bureau ^{210,211} .

Supplementary Table 7.

Program details for the Natural Forest Conservation Program.

Program 7	Natural Forest Conservation Program (天然林保护工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	<p>From 1970–1996, China experienced an annual deforestation rate of 2.67–3.36%, and this loss is widely believed to have contributed to severe soil erosion and flooding^{25,219}. In response, China's central government launched the Natural Forest Conservation Program to halt the logging of natural forests; control deforestation; protect natural forests; and reforest and regenerate existing forests via mountain closure, aerial seeding, and artificial planting^{6,8,220}.</p> <p>To achieve the overall goal of protecting and restoring natural forests, the program has developed short-, medium-, and long-term goals³:</p> <ul style="list-style-type: none"> Short-term (1998–2000) goals: eliminate (in the middle and upper reaches of the Yellow River and the upper reaches of Yangtze River) or reduce (in northeast China, Inner Mongolia, Hainan and Xinjiang) timber harvesting from natural forests and create alternative business opportunities for traditional forest enterprises. Medium-term (2001–2010) goals: plant and conserve forests for ecological benefits and increase timber harvesting from plantation forests. By the end of 2010, this program increased forest area by 0.13 billion mu (8.67 million ha) and forest cover by 3.72%²²¹, compared to 2000 levels. Long-term (2011–2050) goals: restore natural forest resources and meet domestic demand for timber via plantation forests. From 2011–2020, increase new forest area 78 million mu (5.2 million ha) and achieve a net increase forest stock of 1.1 billion cubic meters, add 416 million tonnes of carbon sink and create 648,500 jobs in forest management²²².
Time frames	<p>Pilot Phase: 1998–2000.</p> <p>1st Phase: 2001–2010.</p> <p>2nd Phase: 2011–2020.</p>
Planned investment	<p>1st Phase: Planned investment of 96.2 billion yuan.</p> <p>2nd Phase: Planned investment of 224.02 billion yuan, in which 219.52 billion yuan will come from central government and 24.50 billion yuan will be contributed by local governments²²².</p>
Geography	<p>In 1998, this program was piloted in 13 provinces: Inner Mongolia, Heilongjiang, Jilin, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Hubei, Shaanxi, Gansu, Qinghai, and Xinjiang.</p> <p>In 2000, the program was officially launched in 17 provinces: Inner Mongolia, Heilongjiang, Jilin, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Hubei, Tibet, Shanxi, Shaanxi, Gansu, Ningxia, Qinghai, Henan, and Xinjiang^{8,25,220}, among which 10 provinces were selected as key areas (bolded).</p>
Implementation mechanisms	<p>Main policy measures:</p> <ul style="list-style-type: none"> Ban any further logging of natural forests in the upper and middle reaches of the Yellow river and in the upper reaches of the Yangtze River. Reduce timber harvesting from natural forests in northeast China, Inner Mongolia, Hainan and Xinjiang. Implement tree plantation by artificial planting and aerial seeding, and close mountains for forest rehabilitation and regeneration. Relocate traditional forest workers through employment in forest protection, one-time relocation, and business development. <p>1st Phase investment was provided by the central and local governments, which largely went towards compensating economic losses of traditional forest enterprises caused by the shift from timber harvesting to tree plantation and forest management⁸ at the following payment rates²²²:</p> <ul style="list-style-type: none"> 1,050 yuan ha⁻¹ (including 840 yuan ha⁻¹ from the central government) for allowing forest regeneration through mountain closure. 750 yuan ha⁻¹ including (600 yuan ha⁻¹ from the central government) for aerial seeding. 3,000 yuan ha⁻¹ (including 2,400 yuan ha⁻¹ from the central government) and 4,500 yuan ha⁻¹ (including 3,600 yuan ha⁻¹ from the Central government) for artificial planting in the Yangtze and Yellow river basins, respectively. 12,000 yuan person⁻¹ yr⁻¹ for education grant; 6,000 yuan person⁻¹ yr⁻¹ for health benefits in the upper reach of Yangtze River and the upper and middle reach of Yellow River; 2,500 yuan person⁻¹ yr⁻¹ for health benefits in the Northeastern area 10,000 yuan per worker for protecting individual 340 ha forest patches <p>2nd Phase investment was provided by the central government only and involved increased compensation rates on national public welfare forest construction, forest management, and employee social insurance²²² at the following rates:</p> <ul style="list-style-type: none"> 1,050 yuan ha⁻¹ for allowing forest regeneration through mountain closure.

	<ul style="list-style-type: none"> • 1,800 yuan ha⁻¹ for aerial seeding. • 4,500 yuan ha⁻¹ for artificial planting in both the Yangtze and Yellow river basins. • 30,000 yuan person⁻¹ yr⁻¹ for education grant; 15,000 yuan person⁻¹ yr⁻¹ for health benefits in the upper reach of Yangtze River and the upper and middle reach of Yellow River; 10,000 yuan person⁻¹ yr⁻¹ for health benefits in northeastern areas; 30,000 yuan person⁻¹ yr⁻¹ for the worker in the government agencies and institutions. • To increase the income of foresters, compensation of 150 yuan ha⁻¹ yr⁻¹ was made available for managing national public welfare forest, and 45 yuan ha⁻¹ yr⁻¹ was made available for managing local public welfare forest.
Performance to-date	<p>Investment and area of reforestation:</p> <ul style="list-style-type: none"> • At the end of 2015, \$35.04 billion (2015 USD) had been invested by the central and local governments. • At the end of 2015, the forest management and protection area of this program was up to 114.58 million ha. Total forest plantation area was 11.90 million ha (includes 0.88 million ha of slash update area), in addition, there are 14.94 million ha of mountain enclosure and 9.56 million ha of forests tending¹⁷¹. • From 1998–2010, forest area increased by 150 million mu (10 million ha); forest stock increased by 725 million cubic meters, carbon sink increased by 360 million tonnes, and forest coverage area increased by 3.7% in the program²²³.
Unintended consequences	The implementation scheme of the 1 st Phase has been criticised as being inconsistent with economic development goals as it has led to declines in revenues to local governments, industries, and forestry workers ⁸ . The central government has modified the policy for the 2 nd Phase ²²⁴ in an effort to address this problem.
Monitoring	Every three years, all levels of government administration (County, Bureau), Provincial, and State Forestry Administration) verify and evaluate program implementation according to accepted methods ²²⁵ .
Level of community engagement	The program adopts hierarchical management from the State, Provincial, to County Forestry Administration. As a result of logging bans and harvest reductions, this program has displaced 0.74 million loggers and other forestry workers, who would be transferred to plantation and forest management activities, retired, or, laid off, mainly depending on their individual willingness ⁶ .

Supplementary Table 8.

Program details for the Grain for Green Program.

Program 8	Grain for Green Program (退耕还林工程)
Governing agencies	State Forestry Administration, Ministry of Finance, and National Development and Reform Commission.
Aims/Objectives	Broad aims are to increase forest cover, alleviate soil erosion, conserve biodiversity, and increase rural household income ^{154,226} . <ul style="list-style-type: none"> 1st Round: convert 14.67 million ha of cropland and 17.33 million ha of barren hills and wasteland to forestland by the end of 2010^{8,227,228}; increase forest cover and prevent soil erosion on cropped hill slopes¹⁵⁴; improve the livelihoods of poor communities by paying rural households money or grain²²⁹; increase forest and grassland coverage by 4.5%²²⁷. 2nd Round: convert 42.4 million mu (2.83 million ha, 1 ha = 15 mu) of cropland to forestland or grassland by the end of 2020; prevent and control soil and water loss, reduce natural disasters, increase carbon sequestration, and tackle climate change; lift groups of destitute communities out of poverty; and promote rural economic development²³⁰.
Time frames	1st Round: 1999–2010. Initiated in 1999 and launched nationwide in 2002. 2nd Round: 2014–2020 ²³⁰ .
Planned investment	1 st Round: 212.81 billion yuan (actual investment) ¹⁷¹ . 2 nd Round: Central government will invest 63.60 billion yuan.
Geography	1 st Round: <ul style="list-style-type: none"> In 1999, the program was piloted in 3 provinces: Sichuan, Shaanxi, and Gansu. In 2000, the program was expanded to 17 provinces (autonomous regions and municipalities): Hebei, Shanxi, Inner Mongolia, Jilin, Heilongjiang, Henan, Hubei, Hunan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Ningxia, Qinghai, and Xinjiang. In 2002, the program was officially implemented in 25 provinces: Heilongjiang, Jilin, Liaoning, Inner Mongolia, Beijing, Tianjin, Hebei, Henan, Anhui, Hubei, Hunan, Jiangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Guangxi, Shanxi, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, and Tibet^{8,19,220}. 2 nd Round: <ul style="list-style-type: none"> In 2014, the program was implemented in 10 provinces: Shanxi, Hubei, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, and Xinjiang²³¹.
Implementation mechanisms	1 st Round: <ul style="list-style-type: none"> The central government subsidized farmers with seeds or seedlings, grain, and cash. Subsidies lasted 8 years for ecological forest, 5 years for economic forest, and 2 years for grassland plantation. Before 2004, participating rural households were provided with grain at a rate of 2,250 kg ha⁻¹ yr⁻¹ in the South China and Yangtze River regions, and 1,500 kg ha⁻¹ yr⁻¹ in the northern and Yellow River regions. After 2004, grain supply turned to cash subsidies at a rate of 1.4 yuan per kilogram of grain. In addition, a living subsidy of 300 yuan ha⁻¹ yr⁻¹ was paid for eligible land^{6,232}. Since 2007, to lift farmers in the implementing areas out of poverty, after the expiry of grain and living subsidies, participating rural households were continuously paid cash subsidies at a rate of 1575 yuan ha⁻¹ yr⁻¹ in the South China and Yangtze River regions, and 1050 yuan ha⁻¹ yr⁻¹ in the northern and Yellow River regions²³³. Land rights of the individuals who engage in land use and management change by contract under the program were recognized. 2 nd Round: <ul style="list-style-type: none"> To further consolidate the achievements of the program and to accelerate poverty alleviation in poor areas, the State Council of China approved the “Overall program of a new round grain for green” to start a new program round in 2014. In this round, the program changed the policy of <i>government-led, farmers voluntary</i> in 1st Round to <i>farmers voluntary, government guidance</i>. This emphasized that land should be voluntarily enrolled by farmers, with the role of the central government overseeing the total implementation area for each province and allocating funds via the provincial government. In this Round, respecting the wishes of farmers was primary, and decisions whether to return farmland to forest or grassland and the species planted were determined by the farmers themselves. Land eligible for conversion was restricted to areas with slope greater than 25 degrees, areas that are subject to severe desertification, and important water source areas with slopes between 15 and 25 degrees. The program shifted its emphasis to the areas managed by poorer communities and heavy poverty alleviation pressures. Direct subsidies were paid to participating rural households at the rate of 1,200 yuan mu⁻¹ cash and 300 yuan mu⁻¹ seedlings for returning cropland to forest and 850 yuan mu⁻¹ cash and 150 yuan mu⁻¹ grass seed for returning cropland to grass. The subsidies of returning cropland to forest were allocated to local

	government at three time periods: 800 yuan mu ⁻¹ (including 300 yuan mu ⁻¹ seedlings) in the first year, 300 yuan mu ⁻¹ in the third year and 400 yuan mu ⁻¹ in the fifth year. Subsidies for returning cropland to grassland were allocated at two time periods, 600 yuan mu ⁻¹ (including 150 yuan mu ⁻¹ grass seed) in the first year and 400 yuan mu ⁻¹ in the third year ²³⁰ .
Performance to-date	At the end of 2015, \$54.57 billion (2015 USD) had been invested by the central and local governments ^{170,171} . The total implementation area of this program was 31.3 million ha from 1999–2015, and from 2000–2015 the implementation area was 30.85 million ha, including 24.93 million ha of forest plantation (8.44 million ha of cropland conversion), 3.4 million ha of mountain enclosure, 2.47 million ha of grassland plantation, and 0.05 million ha of tending and recovery of burned, bare, or abandoned mine land or disaster area ¹⁷¹ . Forest coverage in the program area has increased more than 3% ²³⁴ . Water erosion, soil loss, and wind and sand impact has dramatically declined. The income of rural households in the implementation area increased from 2,761 yuan in 2000 to 6,050 yuan in 2012 (2015 yuan) ²³⁴ , and the program has become the largest rural poverty reduction program in China so far. Developments of subsequent industries (e.g. production forest, timber forest, bamboo, plantation of herbs, livestock, and eco-tourism) have become key sources of the growth of income for local farmers. Some studies have shown that this program has had only a small effect on China's grain production and almost no effect on prices or China's future grain supply ^{235,236} and can increase the carbon sequestration and alleviate soil erosion. However, due to local differences of natural conditions, in some regions this program has increased the severity of water shortages and adversely affected the number of species present ²³⁷ . Long-term sustainability is also under question as some farmers may reconvert the land back to cultivation after the program ends ²³⁸ .
Unintended consequences	Recent expansion of the program has led to regional deficits of food supplies due to reduced availability of farmland. Vegetation has been degraded in arid and semi-arid areas because of reduced soil water availability and mismanagement of planted vegetation. Expansion of forest areas has caused significant declines in downstream flows in the Yellow and the Yangtze Rivers, which has created a tension with increased water demand for growing populations and industrial and agricultural production activities ⁵⁷ . Monocultures or simple mixed forests overwhelmingly dominate Grain for Green forests. This program has resulted in major losses of bird and bee diversity ⁸⁶ .
Monitoring	Local government officers are responsible for monitoring, but monitoring and evaluation are considered to be insufficient ^{8,239} . In 2016, the State Forestry Administration issued <i>Specification of Monitoring and Evaluation of Ecological Benefits of the Grain for Green Program</i> ²⁴⁰ in an effort to rectify this.
Community engagement	The program has been adopted in 2,279 counties spanning 25 provinces, accounting for 82% of the total territory of China ²⁴¹ . Over 32 million rural households and 124 million farmers have participated in the program ^{8,19} .

Supplementary Table 9.

Program details for the Fast-growing and High-yielding Timber Program.

Program 9	Program of the Base Construction of Fast-Growing and High-Yielding Timber Forest (重点地区速生丰产用材林基地建设工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	The banning of logging of natural forests in the upper and middle reaches of the Yellow River and upper reaches of the Yangtze River since 2000 under the Natural Forest Conservation Program has dramatically reduced timber production in key state-owned forest regions in northeast China, Inner Mongolia, Hainan, and Xinjiang. This program was instigated to remedy the decline in timber supply without impacting natural forest resources via the establishment of fast-growing and high-yielding timber plantations. By the completion of the program, the program aimed to establish forest plantations of fast-growing and high-yielding timber species across 13.33 million ha (afforestation 6.18 million ha and reforestation 7.15 million ha), and to supply 133.37 million cubic meters of timber resources per year, accounting for about 40% of domestic demand. When combined with existing timber resources, the program aimed to meet domestic demand ²⁴² .
Time frames	1 st Phase: 2001–2005. 2 nd Phase: 2006–2010. 3 rd Phase: 2011–2015.
Planned investment	Planned level of investment is 71.8 billion yuan from 2001 to 2015. 1 st Phase: 25.6 billion yuan. 2 nd Phase: 24.6 billion yuan. 3 rd Phase: 21.6 billion yuan.
Geography	To complement existing timber plantations, this program mainly targets areas east of the 400 mm rainfall isohyet and prioritizes areas above 600 mm rainfall with gentle topography as the base construction areas. Four regions are identified: <ol style="list-style-type: none"> Guangdong, Guangxi, Hainan, and Fujian region, including 24 projects (14 for wood pulp/paper raw material, 8 for man-made plank material and 2 for large diameter wood raw material) with an area of 1.99 million ha. The middle and lower reaches of the Yangtze River region, including 36 projects (8 for wood pulp/paper raw material, 25 for man-made plank material and 3 for large diameter wood raw material) with an area of 3.07 million ha. The middle and lower reaches of the Yellow River region, including 17 projects (7 for wood pulp/paper raw material and 10 for man-made plank material) with an area of 1.05 million ha Northeast Inner Mongolia region, including 22 projects (10 for wood pulp/paper raw material, 7 for man-made plank material, and 5 for large diameter wood raw material) with an area of 7.22 million ha²⁴². The implementation of the 1 st Phase (2001–2005) focused on forest construction for industrial raw materials for development in southern China. The 2 nd Phase (2006–2010) and the 3 rd Phase (2011–2015) aimed to complete the construction in both northern and southern China ²⁴² .
Implementation mechanisms	Four factors are considered to define priority areas for timber plantations under this program ²⁴² . <ul style="list-style-type: none"> Located outside of the Natural Forest Conservation Program areas. Located in areas with suitable geographical conditions, with over 400 mm annual precipitation or potential for irrigation. Located near processing facilities for wood pulp, papermaking, and man-made board, to enable ease of management and transportation. Located in areas with local governments and the masses have experience of fast growing forest construction and high enthusiasm. The base construction adopts sole proprietorship, cooperation, contract, shares and other forms, to establish a leading ‘enterprise + farmer cooperative economy organization + farmers’, ‘enterprise + base + farmers’, ‘Bureau of Forestry + base + farmers’, and other management mechanisms to share the benefit and risk, as well as rights and responsibility ²⁴² . Timber plantations are established through acquisition, joint management, joint ventures, and contracts. Social investment and engagement is major requirement and national support is complementary. State investment is mainly used as subsidies for high quality seedlings, as well as forest fire prevention, pest control, forest infrastructure, new technology development and promotion. Forest plantation funds mainly come from loans which are expected to account for 70% of project construction budget. According to the national benchmark interest rate, central and local government give a 3% discount respectively. In addition to state subsidies and subsidized loans, the remaining need to be covered by forestry companies ²⁴² .
Performance to-date	As of 2011, the central government has completed a total investment of 302.28 million (2015 USD), and the total afforestation area is 226,730 ha. The program has largely underspent and under-delivered on planned targets. Due to a variety of reasons including

	a lack of policy support, the area of timber forest plantation was gradually reduced ²⁴³ . Other reasons for the underperformance of the program include a lack of financing channels and diversified investment and financing options. Resource management was also imperfect, as operators could not cut according to market demand and investments could not provide timely returns, which reduced the enthusiasm of investors. Unreasonable levies, including up to 30 kinds of taxes and fees has become an obstacle to the implementation of the project. Difficulties in forestland intensive management and a low level of timber production also reduced program performance ²⁴³⁻²⁴⁵ .
Unintended consequences	Fast-growing and high-yielding timber plantations in southern China have led to concerns around depleting soil nutrients and groundwater resources, and creating competition with agricultural crops for water and high-quality land ²⁴⁶ .
Monitoring	The main responsibilities of the government departments are to oversee the development and management of the base construction, and coordinate and facilitate relationships between industries and departments. The government also prioritises productivity, layout, and industrial policy-making, to formulate the economic regulation and resource management for the base construction, to improve the service of providing market information, and to strengthen the supervision mechanism and detect problems in the construction and operation of the base ²⁴² . As for project management, the government has allowed a much greater role for market mechanisms. Forestry enterprises take overall responsibility for the construction of the base according to the design and the need of the market, legal aspects, bidding system, project supervision, and financial reimbursements ²⁴² .
Level of community engagement	The scope of this program relates to Hebei, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hunan, Hubei, Guangdong, Guangxi, Hainan, and Yunnan province, involving 886 county (city, district) and 114 Forestry Bureau in 18 provinces ²⁴² .

Supplementary Table 10.

Program details for the Forest Ecosystem Compensation Fund.

Program 10	Central Government Forest Ecosystem Compensation Fund Program (中央财政森林生态效益补偿基金工程)
Governing agencies	State Forestry Administration and Ministry of Finance
Aims/Objectives	The main purpose of the Forest Ecosystem Compensation Fund Program is for the restoration, protection, and management of non-commercial forest ecosystems, and to compensate for the economic losses of managers or owners that might otherwise have generated profits from commercial uses of forest ecosystems ²⁴⁷ . The main objective is to protect and improve the living environment, to maintain ecological balance, and protect species through management of forests which have important ecological, biodiversity conservation, and sustainable economic and social values.
Time frames	Pilot Phase: 2001–2003. 1 st Phase: 2004–2009. 2 nd Phase: 2010–2012. 3 rd Phase: 2013–2016.
Planned investment	The amount of investment is determined according to the area requiring compensation. According to estimates, a reasonable compensation standard should be 540–750 yuan ha ⁻¹ yr ⁻¹ ^{248,249} , and the current compensation standard is 225 yuan ha ⁻¹ yr ⁻¹ , so the future compensation may increase greatly.
Geography	<p>The Forest Ecosystem Compensation Fund Program is mainly directed towards protection and management of national non-commercial forest as defined by the National Forestry Bureau and the Ministry of Finance as²⁵⁰:</p> <ul style="list-style-type: none"> • The source of important rivers. The trunk stream and primary tributaries where the source drainage area is more than 10,000 km². • The sides of important rivers. To the north of the Yangtze River, the sides of first level tributaries > 150 km in length and with a drainage area > 1,000 km². To the south of the Yangtze River, the sides of first level tributaries > 300 km in length and drainage area > 2,000 km². • National Nature Reserve and land designated on the World Natural Heritage List. • Wetlands and reservoirs of importance. • Forest within 10 km of the national border. • Areas at risk of desertification or serious soil erosion including the main trunk shelterbelt of windbreak forests; concentrated forest, woodland and shrubland patches with area > 30 ha. • The coastal shelterbelt forest, first coastal mountain forest ridge at the western Taiwan Strait. • State-owned forest reservation. <p>The amount and geography of non-commercial forest is defined as (note that not all the defined non-commercial forest can be compensated)²⁵¹:</p> <ul style="list-style-type: none"> • 5.067 million ha of river source areas. • 24.8 million ha in the sides of important rivers. • 8.933 million ha of protected areas and natural heritage areas. • 5.333 million ha of wetlands and reservoir areas. • 4.933 million ha of border areas. • 49 million ha of desertification and soil erosion areas. • 1 million ha of coastal shelterbelt and mangrove forest areas; as well as other areas.
Implementation mechanisms	<p>The standards of compensation for managing state-owned, collective, and individually-owned forest are 75 yuan ha⁻¹ yr⁻¹, increasing to 150 yuan ha⁻¹ yr⁻¹ for collective and individually-owned forest from 2010–2012²⁵², and to 225 yuan ha⁻¹ yr⁻¹ for collective and individually-owned forest from 2013.</p> <p>The forest authority signs a forest protection contract with the state-owned units, collectives and individuals who undertake forest management and protection.</p> <p>The provincial finance and forestry departments jointly apply to the Ministry of Finance and the State Forestry Administration for financial compensation from the fund before April 30th of each year.</p> <p>According to the defined forest area and compensation standards, the Ministry of Finance will determine the amount of compensation paid.</p>
Performance to-date	<p>As of 2015, the central government had invested \$16.122 billion (2015 USD). The national public-welfare forest designated by the state is more than 120 million ha and the annual compensation area is more than 97.33 million ha involving 30 provinces across the country²⁵³.</p> <p>The implementation of the program has made an important contribution to the improvement of forest quality and the improvement of the ecological environment²⁵². The program effectively alleviates the conflict in objectives between the state (who wants ecological outcomes) and the owners of forest (who want profits)²⁵². According to the seventh forest resources inventory results, the volume of the public-welfare forest is 11.13 m³ ha⁻¹ higher than the national average, and the carbon storage capacity has been significantly enhanced²⁵⁴.</p>

Unintended consequences	This program has faced some problems including low levels of compensation, incomplete coverage of compensation, and compensation has not increased in line with economic development ^{251,254,255} .
Monitoring	The State Forestry Administration conducts random checks of the requisition and occupancy. Those units and individuals found to be in violation of the provisions, or who have misappropriated or caused the loss of funds, will be punished in accordance with the relevant provisions of the "fiscal violations penalties and punishment regulations". Violations result in a 20% reduction in payments from the central government financial compensation fund ²⁵⁶ .
Level of community engagement	The program covers 30 provinces and 70 million farmers have benefitted from it ²⁵⁴ .

Supplementary Table 11.

Program details for the Sandification Control Program – Beijing/Tianjin.

Program 11	The Sandification Control Program for Areas in the Vicinity of Beijing and Tianjin (津京风沙源治理工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	<p>Sandstorms have increased in frequency in China over the last half of the twentieth Century. In the 1990s, Beijing, Tianjin, and North China repeatedly suffered wind erosion and sandstorm events of unparalleled frequency, extent, and magnitude, culminating in the spring of 2000, 12 consecutive significant events characterized by dust, blowing sand, and sandstorm weather across northern China. These affected Beijing particularly acutely which suffered 7 successive events in one month.</p> <p>In order to improve and optimize the ecological environment in Beijing, Tianjin and the surrounding areas, to reduce the risk of sandstorms, the State Council launched the Sandification Control Program, planned for 2 Rounds:</p> <p>1st Round:</p> <ul style="list-style-type: none"> The main aim is the conversion of 2.63 million ha of cropland to forestland, afforestation of 4.94 million ha, and grassland management over 10.63 million ha. In addition, construct 66,059 water sources projects, 47,830 water saving irrigation projects, and manage 2.34 million ha of small watersheds, and relocate 180,000 people²⁵⁷. <p>2nd Round:</p> <ul style="list-style-type: none"> By 2022, the program aims to consolidate the achievements of the first Round, and to establish basic governance of desertified lands. Further, the program aims to arrest the trend in land desertification expansion, significantly improve the ecological environment and ecosystem stability. A major aim is to construct a green barrier between Beijing and Tianjin and the northern part of North China, significantly reducing dust weather in Beijing and Tianjin, and further reducing the impact of sandstorm hazards. The program includes 7 major tasks: including strengthening vegetation protection and forest plantation, improving the quality and coverage of existing vegetation, strengthening desertified land management in key areas, curbing sand erosion in certain areas, promoting the relocation of 370,400 people, and reducing regional ecological pressure on land²⁵⁸.
Time frames	<p>1st Round: 2001–2012.</p> <p>2nd Round: 2013–2022.</p>
Planned investment	<p>1st Round: 55.87 billion yuan²⁵⁷.</p> <p>2nd Round: 87.79 billion yuan²⁵⁸.</p>
Geography	<p>1st Round: 75 counties from five provinces, including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia. The total control area covers 458,000 km², including 101,800 km² of sandy land^{257,258}.</p> <p>2nd Round: 138 counties from six provinces, including Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia and Shan'xi .The total control area covers 706,000 km², including 202,200 km² of sandy land²⁵⁸.</p>
Implementation mechanisms	<p>The program involves several on-ground actions to reduce desertification and wind erosion including the afforestation of barren hills and wastelands, returning farmland to forest, building farmland shelterbelts, prohibiting grazing, establishing small water conservation facilities and water projects, comprehensive management of small watersheds and ecological migration. Subsidies for these actions include:</p> <ul style="list-style-type: none"> Returning farmland to forest: Cash and food subsidies for 8 years, the subsidy is 100 kilograms of grain mu⁻¹ yr⁻¹, 50 yuan mu⁻¹ yr⁻¹ for returning farmland. Seed subsidy for afforestation in the returned land is 20 yuan mu⁻¹²⁵⁷. Afforestation: 300 yuan mu⁻¹ for artificial afforestation, 120 yuan mu⁻¹ for aerial seeding, 70 yuan mu⁻¹ for mountain enclosure²⁵⁷. Grassland treatment: Artificial grass 120 yuan mu⁻¹, aerial seeding 100 yuan mu⁻¹, grassland enclosure 70 yuan mu⁻¹, grassland base construction 500 yuan mu⁻¹²⁵⁷. Water control: the subsidy is 10,000 yuan for each water saving projects, and 200,000 yuan km⁻² for comprehensive management of small watersheds²⁵⁷. Relocation: 5,000 yuan per person²⁵⁷. <p>Provinces, in accordance with the central investment plan, allocate actions to counties, and counties organize the annual implementation plan²⁵⁷. Project legal representatives are appointed which manage the bidding system and implement contract management²⁵⁷. Project funds use a special account, strictly for the construction of state-approved content according to the project schedule, and is prohibited for other purposes²⁵⁷.</p>
Performance to-date	<p>As of 2015, a total investment of \$ 7.95 billion (2015 USD) has been made on sandification control measures covering a total area of 12.88 million ha¹⁷¹.</p> <p>As of 2012, the total of forest plantation completed under the program was 7.53 million ha, including 1.09 million ha of cropland converted to forest. The total area of grassland management was 9.33 million ha, 11 million m² of greenhouses and 127,000 feed machinery units were established, comprehensive management of 15.4 million ha of small watersheds was undertaken, 213,000 water-saving irrigation and water engineering projects were</p>

	<p>installed, and 180,000 people relocated²⁵⁸.</p> <p>Four major ecological shelterbelts had been constructed, including:</p> <ul style="list-style-type: none"> • Shelterbelts on south edge of Hunshanda sand area. • Shelter belt in the north edge of Yinshan Mountain. • Sand-fixing forest in the border area of Hebei and Inner Mongolia. • Shelterbelts on the eastern margin Mao Wusu Sand land. <p>A comparison of the condition in 2009 compared with that in 2004 revealed²⁵⁸:</p> <ul style="list-style-type: none"> • Fixed sand from 5.42 million ha up to 5.52 million ha, an increase of 1.75%. • Semi-mobile sandy land decreased from 0.936 million ha 0.836 million ha, a 10.67% decrease. • Sandy flow decreased from 0.335 million ha to 0.233 million ha, a 30.68% decrease. • A comparison of the condition in 2010 compared with that in 2001 revealed²⁵⁸: • Soil erosion area decreased by 39.1% (from 15.91 million ha to 9.69 million ha). • The total amount of wind erosion reduced by 29% (from 1.191 billion tonnes to 0.846 billion tonnes). • The total amount of dust releases declined by 16.2% (from 31 million tonnes to 26 million tonnes). <p>A comparison of the condition in 2010 compared with that in 2008 revealed²⁵⁸:</p> <ul style="list-style-type: none"> • Forest coverage rate increased to 15.01%, an increase of 4.07 percentage points. • The woodland area of 14.462 million ha, experienced an increase of 1.337 million ha. • The total volume of live wood is 21.08 million m³, which is nearly double of result of the sixth survey (1999–2003).
Unintended consequences	The tree species planted in arid and semi-arid areas in this program consume more water than native plants. The planted trees do not adapt to local arid and semi-arid conditions, and can largely die if irrigated water supply (mainly using groundwater resources) stops. The planting of unsuitable trees (for instance, aspens in the north and eucalyptus and rubber trees in the south) can also be seen in other afforestation programs in China ²⁶ . Additionally, monoclonal plantations lack diversity and have great potential risk to be seriously damaged by pests and diseases ²⁴⁶ .
Monitoring	Implementation of household contract policy, clear governance, management responsibility and profit rights as supporting institutions. To establish and improve management of lands under the program, part-time management personnel were employed with the general role of implementing the "three prohibitions" (no reclamation, grazing, firewood collection). After the project is completed, the relevant departments organize the inspection and acceptance process. Those that fail to qualify will be deducted from the annual investment, or the project may be terminated ²⁵⁷ .
Level of community engagement	1 st Round: the population involved in the project area was 19.58 million, of which agricultural population is 16.22 million or 82.9% of the total population, 4.40 million people or 22.5% of the total population were in poverty. A total of 180,000 people were relocated ^{257,258} .

Supplementary Table 12.

Program details for the Wildlife Conservation and Nature Protection Program.

Program 12	The Wildlife Conservation and Nature Reserve Protection Program (野生动植物保护及自然保护区建设工程)
Governing agencies	State Forestry Administration.
Aims/Objectives	<p>Aims to expand the number of nature reserves and enhance the protection of wildlife and its habitat, and promote sustained, stable, and healthy development. Phase aims include²⁵⁹:</p> <ul style="list-style-type: none"> • 1st Phase: increase the number of natural reserves to 1800, including 220 national reserves, and increase the total area of reserves to 155 million ha. • 2nd Phase: increase the number of natural reserves to 2000, including 280 national reserves, and increase the total area of reserves to 164.2 million ha. • 3rd Phase: increase the number of natural reserves to 2500, including 350 national reserves, and increase the total area of reserves to 172.8 million ha. <p>The program involves the following four actions²⁵⁹:</p> <ul style="list-style-type: none"> • Key wild animal and plant conservation. 15 rare and endangered wild animals and plants including panda, crested ibis, tiger, gold monkey, Tibetan antelope, Chinese alligator, Asian elephants, gibbons, musk deer, Przewalski's horse, deer, crane, pheasants, orchid plants and cycads. • National key ecosystem protection and natural reserve construction in forest, desert, and wetland ecosystems. • Establishing national key scientific research and monitoring networks, including the Science and Research System, the National Wildlife and Wetland Resources Monitoring System, National Bird Banding Center and Banding Network, and establishing a wildlife species DNA fingerprint file. • Establishing wildlife protection authorities at different levels: prefecture, municipality, county, and township.
Time frames	<p>1st Phase: 2001–2010.</p> <p>2nd Phase: 2011–2030.</p> <p>3rd Phase: 2031–2050.</p>
Planned investment	<p>From 2001–2030, the program planned to invest 135.65 billion yuan, comprised of 66.44 billion yuan from central government, 31.69 billion yuan from local government, and 37.53 billion yuan from community funds²⁵⁹.</p> <p>1st Phase:</p> <ul style="list-style-type: none"> • 2001–2005: planned to invest 39.81 billion yuan, including 21.48 billion yuan from central government, 9.33 billion yuan from local government, and 9.0 billion yuan from community funds. • 2006–2010: planned to invest 35.47 billion yuan, including 18.10 billion yuan from central government, 8.85 billion yuan from local government, and 8.52 billion yuan from community funds. <p>2nd Phase:</p> <ul style="list-style-type: none"> • Planned to invest 60.38 billion yuan, including 26.86 billion yuan from central government, 13.51 billion yuan from local government, and 20.1 billion yuan from community funds.
Geography	<p>The program covers the whole country and includes the following key regions^{259,260}:</p> <ul style="list-style-type: none"> • Mountain and plain area in the northeast of China. • Plateau and desert area in Inner Mongolia and Xinjiang Uygur Autonomous Region. • Loess Plateau region in the North China Plain. • Alpine area in the Tibetan Plateau. • Mountain canyon area in the southwest. • Hilly region in western and southern China. • Hilly and plain region in eastern China. • Low mountain and hilly region in southern China.
Implementation mechanisms	<p>Standards for investment under the program under the 1st Phase are²⁵⁹:</p> <p>National key wildlife conservation projects:</p> <ul style="list-style-type: none"> • Reserve construction: 30 million yuan per each for giant panda; 24 million yuan each for other wild animals' protection; 20 million yuan each for wild plants protection. • Sanctuary construction: 10 million yuan each for wild animals and 8 million yuan per each for wild plants. • Breeding center and training base: 30 million yuan each for the above 15 rare and endangered wild animals and plants. • Protection station: 1 million yuan each. • Research and monitoring stations and sites: 2 million yuan for each station and 0.8 million yuan for each site. • Wildlife habitat restoration and improvement: 3,000 yuan ha⁻¹. <p>National key ecosystem conservation projects:</p>

	<ul style="list-style-type: none"> Forest ecosystem: 20 million yuan for each tropical reserve; 24 million yuan for each subtropical reserve; 28 million yuan for each temperate reserve. Desert ecosystem: 28 million yuan each. Wetland ecosystem: 150 million yuan for each wetland reserve in the source of the Yangtze River, Yellow River, and Lancang River; and 60 million yuan each for other rivers. Conservation cells and biological diversity cells: 0.4 million yuan each, including 0.2 million yuan from central government and 0.2 million yuan from local government. <p>National research and monitoring network construction projects:</p> <ul style="list-style-type: none"> 75 million yuan for each national research and development center; 40 million yuan for each state animal and plant monitoring center; 30 million yuan for each state wetland monitoring center; 3 million yuan for each provincial research institute; 5 million yuan for each provincial animal and plant monitoring station; 4 million yuan for each provincial wetland monitoring station; 20 million yuan for each wetland education center; 0.8 million yuan for each animal and plant monitoring site; and 1 million yuan for each wetland monitoring station. 20 million yuan for each national bird banding center; 4 million yuan for each national bird banding station. 30 million yuan for each animal and plant inspection center. <p>Wildlife industry base construction projects:</p> <ul style="list-style-type: none"> Animal rescue breeding base: 10 million yuan each, of which 5 million yuan comes from the central government. Plant breeding base: 8 million yuan each, of which 4 million yuan comes from the central government. Wild zoo: 200 million yuan each, all from community funds. Wild animal farm: 5.5 million yuan each, of which 0.25 million yuan comes from the central government. Wildlife natural stocking: 30 million yuan each, of which 10 million yuan comes from the central government. Hunting grounds: 5.6 million yuan each, of which 0.8 million yuan comes from the central government. Wildlife primary market: 40 million yuan each, of which 10 million yuan comes from the central government. State wildlife secondary market: 2.75 million yuan each, of which 0.25 million yuan comes from the central government. <p>2nd Phase:</p> <ul style="list-style-type: none"> Investment will increase 50% from the 1st Phase.
Performance to-date	<p>At the end of 2015, \$ 2.4 billion (2015 USD) had been invested by government, increasing the nature reserve area by 21.25 million ha from 2000–2015¹⁷¹.</p> <p>At the end of 2014, the number of forest nature reserves reached 2,174, which included 344 nature reserves at the national level, with a total area of 124 million ha and covering 12.98% of China's land area²⁶¹.</p>
Unintended consequences	Nature reserves identified in this program are mostly in remote and poor areas, and the contradiction between poverty elimination and ecological protection is dominant. Ongoing economic development in nature reserves has resulted in the fragmentation of ecosystems and degraded their ecological function ²⁶² .
Monitoring	<p>Actions are implemented following specifications under the <i>Planning of National Wildlife conservation and Nature Reserve Construction</i>.</p> <p>In order to manage the tension between development and nature protection and mitigate ongoing threats from development, the State Council has released the <i>Notice on management of nature reserves work</i>²⁶³ and <i>regulation of national nature reserve adjustment</i>²⁶⁴, which emphasises:</p> <ul style="list-style-type: none"> All modification and monitoring will be in the charge of Environmental Protection Department under the State Council. The Review Committee of National Nature Reserve is responsible for reviewing work under the program and adjusting functional areas. Once the nature reserve is established, it should not be adjusted within 5 years. If the scope of nature reserve has to be adjusted, the core and the buffer zone areas should not be narrowed and the effective protection of the main protected object should be ensured. Application to adjust the scope of national nature reserves by the provincial (autonomous region or municipality) government or the relevant administrative department under the State Council should directed to the State Council. If unauthorized modification to the national natural reserve occurs or it is not in accordance with the approved plan, the relevant department under the State Council shall direct investigation, rectification and punishment. If the national nature reserve is seriously damaged and loses its conservation value, the State Council can cancel it according to the approved program and then apply the legal liability to the responsible person(s).
Level of community engagement	<p>At the end of 2014 the program had promoted the following engagement¹⁷¹:</p> <ul style="list-style-type: none"> 5,892 wildlife provenance breeding bases. 1,070 wild plant provenance breeding bases. 4,544 wildlife management stations. 116 bird banding centers. 1,418 wild animal epidemic sources and disease monitoring stations. 633 wildlife research and testing organizations. 52,700 persons engaged in the wildlife and nature reserve construction.

Supplementary Table 13.

Program details for the Partnership to Combat Land Degradation.

Program 13	PRC-GEF Partnership to Combat Land Degradation in Dryland Ecosystems (中国-全球环境基金干旱生态系统土地退化防治伙伴关系)
Governing agencies	The program involves multiple Chinese and international agencies including ²⁶⁵ : <ul style="list-style-type: none"> • Central Project Steering Committee led by the Ministry of Finance and State Forestry Administration. • Central Project Management Office under State Forestry Administration. • Central Project Coordination Office under Ministry of Finance of the PRC. • National Development Reform Commission. • Legislative Affairs Commission of the National People's Congress Standing Committee. • Legislative Affairs Office of the State Council. • Ministry of Water Resources. • Ministry of Agriculture. • Ministry of Land and Resources. • Ministry of Science and Technology. • Ministry of Environmental Protection. • National Meteorological Administration. • Chinese Academy of Sciences. • Leading Group for Poverty Alleviation and Development Office of the State Council. • Global Environment Facility (GEF) implementing agencies (including the World Bank, the Asian Development Bank, and the International Fund for Agricultural Development). • Provincial Project Coordination Offices. • Provincial Project Management Offices (PPMOs).
Aims/Objectives	1 st Phase: The program aims to establish an inter-agency, inter-regional, and sustainable natural resources management framework to further strengthen capacity-building in the western regions of China in the context of climate change adaptation and biodiversity conservation, to promote sustainable socio-economic development, and to provide innovative and beneficial knowledge to global land degradation issues that contribute to the well-being of all human kind ^{265,266} . 2 nd Phase: Aims to improve management of land and water resources, reduce poverty, increase incomes, protect biodiversity, and combat climate change in Western PRC. It also aims to bring agencies together in a new and broader partnership, to work synergistically with innovative and focused approaches, and to achieve rapid benefits for people and land systems. Through implementation for the forthcoming 10 years, local people will benefit (compared with a baseline in 2013) through: Degraded land improved by Sustainable Land Management (SLM), with 50% of the “manageable degraded land” under control and conditions improved; Vegetation coverage increased ,and the forested area increased by 1.5–3.0%; Land productivity increased by 5–10%; Water resources management improved, rural drinking water safety issues addressed principally through a significant increase in rural water supply; Per capita income doubled; and poverty reduced, with all the benefits of a prosperous society ²⁶⁵ .
Time frames	1 st Phase: 2003–2012. 2 nd Phase: 2014–2023.
Planned investment	1 st Phase: at the end of 2012, the total investment was US\$ 840.05 million, including US\$ 48.61 million from GEF, US\$ 166.90 million from the World Bank, US\$ 251.60 million from Asian Development Bank, US\$ 7.03 million from the International Fund for Agricultural Development, and US\$ 365.91 million from China's central government, enterprises, and farmers ²⁶⁶ . 2 nd Phase: US\$ 479.43 million from GEF and US\$ 15.32 billion from the Chinese central government ²⁶⁵ .
Geography	1 st Phase: 6 provinces were targeted including Gansu, Inner Mongolia, Ningxia, Shaanxi, Qinghai and Xinjiang. Efforts comprised 8 major projects ^{266,267} : <ul style="list-style-type: none"> • Capacity Building to Combat Land Degradation. • PRC-GEF management and policy support to combat land degradation in dryland ecosystems. • Gansu Province and Xinjiang Pastoral Development Project. • Ningxia Integrated Ecosystem and Agricultural Development Project. • Forestry and Ecological Restoration Project in Three Northwest Provinces (Gansu, Shaanxi and Ningxia) (formerly Silk Road Ecosystem Restoration Project). • An Integrated Ecosystem Management (IEM) Approach to the Conservation of Biodiversity in Dryland Ecosystems Project. • Sustainable Management and Biodiversity Conservation of the Lake Aibi Basin. • Sustainable Development in Poor Rural Areas Project. 2 nd Phase: 11 provinces were targeted including Chongqing, Gansu, Guangxi, Guizhou, Inner Mongolia, Ningxia,

	<p>Qinghai, Shaanxi, Sichuan, Xinjiang, and Yunnan. The initial priority area covers Gansu, Guizhou, Inner Mongolia, Shaanxi, Sichuan and Qinghai²⁶⁵. GEF funded projects associated with the new partnership are:</p> <ul style="list-style-type: none"> • US\$ 10 million for STAR GEF-6 Allocation to SLM in PRC (from 2015 onwards). • US\$ 23.3 million for Sustainable and Climate Resilient Land Management in Western PRC (2015–2017). • US\$ 165.20 million for Shaanxi Weinan Luyang Integrated Saline and Alkaline Land Management Program (2013–2018). • US\$ 29.57 million for An IEM Approach to the Conservation of Biodiversity in Dryland Ecosystem (2011–2016). • US\$ 70.65 million for Qinghai Integrated Land Resource Management Project (2015–2018). • US\$ 180.71 million for Forestry and Ecological Restoration Project in Three Northwest Provinces (2011–2016).
Implementation mechanisms	<p>1st Phase²⁶⁶:</p> <ul style="list-style-type: none"> • US\$ 15 million for Capacity Building to Combat Land Degradation. • US\$ 11.43 million for PRC-GEF management and policy support to combat land degradation in dryland ecosystems. • US\$ 112.42 million for Gansu Province and Xinjiang Pastoral Development Project. • US\$ 221.05 million for Ningxia Integrated Ecosystem and Agricultural Development Project. • US\$ 180.70 million for Forestry and Ecological Restoration Project in Three Northwest Provinces. • US\$ 29.57 million for An IEM Approach to the Conservation of Biodiversity in Dryland Ecosystems Project. • US\$ 12.18 million for Sustainable Management and Biodiversity Conservation of the Lake Aibi Basin. • US\$ 158.30 million for Sustainable Development in Poor Rural Areas Project. • US\$ 82 million for Shaanxi Weinan Luyang Integrated Saline Land Management Project. • US\$ 16.4 million for Sustainable and Climate Resilient Land Management in Western PRC. <p>2nd Phase: 5 factors are taken into account in targeting areas for investment²⁶⁵:</p> <ul style="list-style-type: none"> • Land degradation: the prevalence of desertification by wind erosion; soil erosion in the Loess Plateau; land degradation in the Karst Region; and areas with severe levels of biodiversity loss and wetland degradation. • Poverty distribution: the zones where poverty and land degradation coincide. • The area covered by PRC's Western Development Strategy. • The zone where ecosystems are under most threat from land degradation. • GEF's Land Degradation Focal Area strategy which concentrates on drylands.
Performance to-date	<p>By the end of 2015, a total of \$ 8.15 billion (2015 USD) had been invested, addressing a total area of 8.3 million ha^{265,266}.</p> <p>By the end of 2012, forest stock volume had increased 149.55 million m³ in 6 provinces involved; A total of 60,000 ha of afforestation in 56 counties (the total area of 56 counties account for 17.7% of that of all counties involved);The average annual carbon sequestration of new added forest is 14.37 million tonnes and 6.05 million tonnes for new added grassland²⁶⁷.</p>
Unintended consequences	The implementation of this program through the Integrated Ecosystem Management approach has been hindered by inherent coordination difficulties within the partnership ²⁶⁸ .
Monitoring	Program monitoring is conducted in line with national procedures including national desertification monitoring, national forest resources monitoring, national soil and water erosion monitoring, and rangeland monitoring. Monitoring of people's income and poverty reduction will be carried out according to the annual data collection mechanisms of the National Bureau of Statistics ²⁶⁵ .
Level of community engagement	<p>1st Phase: 2.901 million persons have benefited from the program²⁶⁶, with the average per capita net income of farmers and herdsmen increasing by 85%²⁶⁷.</p> <p>2nd Phase is mainly planned for 9 provinces and 168 counties.</p>

Supplementary Table 14.

Program details for the Rocky Desertification Treatment Program.

Program 14	Rocky Desertification Comprehensive Treatment Program in Karst Area (岩溶地区石漠化综合治理工程)
Governing agencies	The National Development and Reform Commission. State Forestry Administration.
Aims/Objectives	<p>The aims of the program are to curb the expansion of desertification in rocky environments, to improve the ecological environment and maintain national ecological security, and to promote national unity and social harmony. This program is also an important basic project in the western development strategy²⁶⁹. Objectives include:</p> <p>1st Phase:</p> <ul style="list-style-type: none"> To strengthen the protection and construction of vegetation and the sustainable exploitation and utilization of grassland resources. To strengthen the construction of basic farmland, water conservation, and soil erosion projects, as well as rural energy construction, relocation of poor people, rational development and utilization of local resources. To complete rocky desertification treatment of 7 million ha, accounting for 54% of the total area of rocky desertification in the planning area. Increase vegetation area by 9.42 million ha, a coverage increase of 8.9% including the construction and transformation of 770 thousand ha of sloping farmland, the reduction of 280 million tonnes of soil erosion each year, and to control rocky desertification and ecological deterioration caused by human factors within about 10 years²⁶⁹. <p>2nd Phase:</p> <ul style="list-style-type: none"> Treat not less than 5 million ha of karst land area and not less than 2 million ha of rocky desertification area; undertake vegetation construction and protection across 1.95 million ha and increase vegetation coverage rate by 2%. Continue the decline in regional soil erosion volumes and curb the desertification expansion trend. Achieve per capita net income growth rate for farmers higher than the national average²⁷⁰.
Time frames	1 st Phase: 2008–2015 ²⁶⁹ . 2 nd Phase: 2016–2020 ²⁷⁰ .
Planned investment	1 st Phase: 11.9 billion yuan ²⁷⁰ (actual investment). 2 nd Phase: 2.5 thousand yuan ha ⁻¹ ²⁷⁰ .
Geography	<p>1st Phase: 451 counties in 8 provinces²⁶⁹.</p> <ul style="list-style-type: none"> 2008–2010: 100 key counties (55 counties in Guizhou; 12 counties in Yunnan; 12 counties in Guangxi; 5 counties in Hunan, Hubei, Chongqing, and Sichuan; and 1 county in Guangdong)²⁶⁹. 2011: 451 counties including 200 key counties in Guizhou, Yunnan, Guangxi, Hunan, Hubei, Chongqing, Sichuan, and Guangdong²⁷¹. 2012–2015: 451 counties including 300 key counties across 8 provinces²⁷². <p>2nd Phase: 455 counties in 8 provinces. State investment focus on 200 counties: 50 in Guizhou, 45 in Yunnan, 43 in Guangxi, 22 in Hunan, 20 in Hubei, 10 in Chongqing, and 10 in Sichuan. The remaining 255 counties need to be treated by local government due to the smaller areas of rocky desertification²⁷⁰.</p>
Implementation mechanisms	<p>The central government allocates a certain amount of funds to each key county every year, the investment standard is 2,000 yuan ha⁻¹ in the 1st Phase and 2,500 yuan ha⁻¹ in the 2nd Phase^{269,270}.</p> <p>The State Forestry Administration takes the lead in organizing the implementation of a period of 5 years of rocky desertification large-scale monitoring²⁷⁰.</p> <p>The area is first divided into different regions for more targeted treatment according to the characteristics of karst environments, natural climatic conditions, causes of local rocky desertification, socio-economic conditions, controllability of rocky desertification, the different impact of treatment measures, and different ecological function. These <i>rocky desertification comprehensive treatment areas</i> include: the middle and high mountain, karst rift basin; karst plateau, karst gorge, peak-cluster depression, karst valley, peak-forest plain, and karst depressions²⁶⁹.</p> <p>The treatment measures include: strengthening the protection and construction of vegetation, improving vegetation coverage, developing and utilizing grassland resources sustainably, vigorously developing grazing animal husbandry, protecting and exploiting water and soil resources sustainably, strengthening the construction of basic farmland, speeding-up the construction of rural energy and developing renewable energy sources, and promoting poverty alleviation and relocation in the areas with poor ecological conditions²⁶⁹.</p>
Performance to-date	<p>Total investment under this program up to 2015 was \$1.98 billion (2015 USD)²⁷⁰. Karst land treatment area was 6.6 million ha, which includes a rocky desertification control area of 2.25 million ha²⁷⁰.</p> <p>By the end of 2010:</p> <ul style="list-style-type: none"> 268,000 ha of forestry construction were completed, 410,000 ha of forest and grassland vegetation were restored 6,670 ha of terraces were established on sloping land, and 570,000 m² of livestock sheds, 1.6 million m³ of

	<p>silos, 19,000 km of irrigation and drainage ditches, 1,200 small reservoirs were built.</p> <ul style="list-style-type: none"> 1.6 million ha of rocky desertification were treated in the 100 key counties and 1.43 million ha treated in the other 351 counties. Vegetation coverage increased 16% in the 100 key counties and vegetation biomass increased by 1.15 million tonnes. Vegetation coverage increased by 3.8% in all 451 counties, soil erosion decreased by nearly 60 million tonnes. Soil erosion decreased from the pre-treatment 5.11 million tonnes to 1.7 million tonnes, a decrease of 67%. Per capita GDP growth of 12.9% occurred, with an annual increase in the average per capita net income of farmers of 10.1%^{270,271,273}. <p>As of 2011, the trend in rocky desertification area was transformed from increasing to decreasing. The rocky desertification land area decreased by 960,000 ha, a decrease of 7.4%, an annual reduction of 160,000 ha at an average annual rate of 1.27%. Vegetation coverage in the 451 counties increased by 4.4%. Vegetation structure was improved, the ratio of trees and shrubs was increased by 2.2%, and the proportion of bare land decreased by 0.8%. The conditions for sustainable economic and social development were improved^{270,274}.</p> <p>With the expansion of rocky desertification treatment, soil erosion in small watersheds was controlled, the soil fertility structure was improved, and the sediment reduction effect of various soil and water conservation measures was obvious²⁷⁵.</p>
Unintended consequences	<p>Due to the difficulty in collecting comprehensive and systematic indicator data, the success of treatment outcomes needs more time to accurately assess²⁷⁶.</p> <p>Due to the low standard of national investment, the capital investment gap is large. The 1st Phase of the implementation was carried out in the regions that were relatively easy to treat. Hence, during the 2nd Phase the treatment will be more difficult. Because of the thin soils in karst areas, vegetation survival rates for areas planted in the 1st Phase has been low, and because of lack of funding for follow-up management, plantings may fail²⁷⁷.</p> <p>The maintenance of planted forests did not reach predetermined requirements. The newly built biogas digesters did not receive proper maintenance, and surveys show that in some places the utilization rate of biogas digesters from the original more than 90%, was down to 73%²⁷⁷.</p>
Monitoring	<p>The National Development and Reform Commission takes the lead in coordinating and organizing the work. On the basis of the national inter-ministerial joint conference on ecological environmental construction, the relevant departments are selected according to the requirements of specific treatments, and an interdepartmental coordination mechanism is established.</p> <p>Local governments are responsible for management of rocky desertification control, the main leader of the government is the first person in charge, and the objectives achieved and tasks are under the leadership of local government.</p> <p>Local government or departments should prepare an implementation plan according to the overall planning made by the National Development and Reform Commission, and take it as the basis for implementation.</p> <p>The State Forestry Administration take the lead in organizing and implementing the rocky desertification large-scale monitoring every 5 years. Relying on the existing monitoring and treatment organizations, the National Development and Reform Commission carry out supervision, inspection, and regular assessment on the progress of construction, quality, and use of funds^{269,270}.</p>
Level of community engagement	The total population is 220 million in the 455 counties of karst area, of which 160 million are rural population and 30 million people living in poverty. 102 million people live in the 200 key counties and 17.38 million are in poverty ²⁷⁰ .

Supplementary Table 15.

Program details for the Grassland Ecological Protection Program.

Program 15	The Grassland Ecological Protection Subsidies and Awards Program (草原生态保护补助奖励项目)
Governing agencies	Ministry of Agriculture. Ministry of Finance.
Aims/Objectives	The aims of this program are to protect national ecological security, to promote the development of pastoral areas and herdsmen's income, to maintain national unity and stability in the border area, and to coordinate the development of urban and rural areas ²⁷⁸ . The objectives are to: <ul style="list-style-type: none"> • Increase grassland vegetation coverage in grazing prohibition areas by more than 15%. • Increase biomass yield by more than 50%. • In areas where a balance of grassland and livestock is achieved, increase grassland vegetation coverage by more than 5%, forage yields by more than 10%; improve grassland ecological environment significantly, and curb the overall trend of deterioration²⁷⁸.
Time frames	1 st Phase: 2011–2015. 2 nd Phase: 2016–2020.
Planned investment	1 st Phase: 76.99 billion yuan (actual investment) ^{279,280} . 2 nd Phase: The subsidy amount is paid according to the subsidy implementation area and overall subsidy standard annually.
Geography	Investment is mainly targeted at the 8 northwest provinces: Inner Mongolia, Gansu, Ningxia, Xinjiang, Tibet, Qinghai, Sichuan and Yunnan, and parts of the 5 provinces: Hebei, Shanxi, Liaoning, Jilin, and Heilongjiang.
Implementation mechanisms	Program implementation is devolved to provincial governments to manage program funds, tasks, objectives, and responsibilities via the target responsibility system. Provincial finance and agricultural departments formulate specific payment standards for grazing prohibition subsidies and livestock balance rewards according to the amount of funds and the national subsidy standard ^{281,282} . 1 st Phase: Grazing prohibition subsidies: 90 yuan ha ⁻¹ yr ⁻¹ , livestock balance award: 22.5 yuan ha ⁻¹ yr ⁻¹ , artificial grassland seed subsidy: 150 yuan ha ⁻¹ yr ⁻¹ , comprehensive production subsidies: 500 yuan household ⁻¹ yr ⁻¹ , in addition to a performance appraisal award ²⁸¹ . 2 nd Phase: Grazing prohibition subsidies: 112.5 yuan ha ⁻¹ yr ⁻¹ , livestock balance award: 37.5 yuan ha ⁻¹ yr ⁻¹ , in addition to a performance appraisal award ²⁸² .
Performance to-date	Total investment under this program up to 2015 was \$12.76 billion (2015 USD) ^{279,283} . More than 252.13 million ha of grassland (not including the grassland seed subsidy area) received subsidies or awards every year ²⁸⁴ . By 2012, nearly 20% of the national grassland has had time to recover following grazing prohibition. 46% of the grassland are achieved the status of <i>grass and livestock balance</i> by reducing livestock. Grassland livestock overgrazing rate was 23%, having decreased 7% from 2010. Grassland vegetation coverage reached 53.8%, increasing by 2.8% from the previous year. Pasture production reached 1.05 billion tonnes, the highest yield of the past ten years and an increase of 7.6% from 2010. In 2012, the annual income of the herdsmen in the 268 pastoral counties was 5,924 yuan, an increase of 31.8% compared with 2010. Of this, the grassland subsidies and rewards amounted to 700 yuan, or 12% of herdsmen's income, on average. In 2012, beef, lamb, milk, and wool production in 268 pastoral counties reached 1.45 million tonnes, 1.35 million tonnes, 9.84 million tonnes and 234 thousand tonnes, respectively, increasing by 2%, 1.6%, 9.8%, and 7.2% compared with 2010 ²⁷⁹ . Inner Mongolia grassland vegetation coverage reached 43.6% in 2014, 6.52% higher than 2010, and 13.6% higher than 2000 ²⁸⁵ .
Unintended consequences	Due to the lack of precision in subsidy standards and lack of a scientific basis particularly with regard to adaptation to local conditions, some subsidies and awards have been excessive in some areas while inadequate in other areas. This has produced inequality and conflict in the course of program implementation ²⁸⁶ . Some pasture farmers without grassland cannot access the subsidies and awards via the program which has exacerbated inequity between the local herdsmen. In practice, it has been difficult to guarantee the fairness and timeliness in contracting grassland management to households ²⁸⁷ .
Monitoring	The Ministry of Finance and Ministry of Agriculture allocated subsidies to provincial departments according via provincial application to access central government funding. The provincial finance departments in conjunction with the departments of agriculture and animal husbandry formulate an allocation plan and set up a special funds account. The payment of subsidies occurs via a village-level publicity system and is supervised by local people. The departments of agriculture, animal husbandry, and finance combine with inspection and auditing departments to strengthen supervision and inspection of the implementation of the tasks and acquittal of funds. Local finance and agriculture departments set up a leading group for the protection of grassland ecological protection subsidy mechanism. This group is responsible for the organization, implementation, supervision, and

	management of the subsidy policy for grassland ecological protection. The Ministry of Finance, together with the Ministry of Agriculture, carry out performance appraisals of the implementation of the provincial grassland ecological protection subsidy system each year ^{281,282} .
Level of community engagement	More than 2 million households have received subsidies and awards in 8 provinces ²⁸⁸ .

Supplementary Table 16.

Program details for the Cultivated Land Quality Program.

Program 16	Cultivated Land Quality Protection and Promotion Program (耕地质量保护与提升工程)
Governing agencies	Ministry of Agriculture.
Aims/Objectives	In order to enhance national food security, and the quality, safety, and ecological sustainability of agricultural production, the Ministry of Agriculture leased the Cultivated Land Quality Protection and Promotion Program in 2015 with the following aims ²⁸⁹ : <ul style="list-style-type: none"> At the end of 2020, the national quality of cultivated land must be improved; the problems of arable soil acidification, salinization, nutrient imbalances, shallow topsoil, heavy metal pollution, white pollution (i.e. plastic film), and other issues should be effectively curbed, and soil biota gradually restored. At the end of 2020, the average fertility of cultivated land will be increased by 0.5 grade units; the rate of manure and crop straw nutrients returned to fields up to 60%, increased by 10% and 25%, respectively. The rate of soil testing and fertilization planning should increase to more than 90%, and fertilizer utilization rates should rise to more than 40%, increasing by 7%. By 2030, the national quality of cultivated land should be improved overall, and food production and sustainable agricultural development should also be significantly improved.
Time frames	2015–2030.
Planned investment	At the end of 2015, total investment was 5.3 billion yuan (actual investment).
Geography	The program covers the whole country but with the following specific priority areas ²⁸⁹ : <ul style="list-style-type: none"> Black soil region of north-east China (most of Heilongjiang, Jilin and Liaoning; and part of Inner Mongolia). Tidal soil area of north China and Huang Huai plain (whole of Beijing, Tianjin, Hebei, Shandong, and Henan; and part of Jiangsu and Anhui). Paddy soil area in the middle and lower reaches of the Yangtze River (whole of Hubei, Hunan, Jiangxi, Shanghai, Jiangsu, Zhejiang, and Anhui). Hilly red and yellow soil region of south China (whole of Fujian, Guangdong, Hainan, Chongqing, Sichuan, Guizhou, Yunnan; and part of Jiangxi and Hunan). Irrigation and dry farming region of loess type of north-west China (most of Shanxi, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, and Tibet).
Implementation mechanisms	The program specifies 5 key projects ²⁸⁹ : <ol style="list-style-type: none"> Comprehensive treatment of degraded cultivated land: <ul style="list-style-type: none"> Comprehensive treatment of black soil degradation in the north-east. A number of key counties (cities) will be selected with 2 demonstration areas each covering about 50 thousand mu (3333.33 ha) or more in each key county. Comprehensive treatment of salinized cultivated land in the north. A number of key counties (cities) will be selected with 2 demonstration areas each covering about 10 thousand mu (666.67 ha) or more in each key county. Target areas are irrigated lands where the soil pH is greater than 8.5 or soil salt content is greater than 1 g kg⁻¹. On-ground actions include returning straw to land, mulching, engineering works to reduce salinity, and salt farming. Demonstration areas should be rotated every 3 years. Comprehensive treatment of acidified cultivated land in the south. A number of key counties (cities) will be selected with 5 demonstration areas covering about 10 thousand mu (666.67 ha) or more in each key county. Target areas are irrigated lands where the soil pH is less than 5.5. On-ground actions include the application of lime and soil conditioners, and planting green manure and returning it to the soil. Demonstration areas should be rotated every 3 years. Control and repair polluted cultivated land: <ul style="list-style-type: none"> Remediation of heavy metal pollution to the soil. A number of key counties (cities) will be selected with 2 demonstration areas each covering about 10 thousand mu (666.67 ha) or more in each key county. On-ground actions include the application of lime and soil conditioners to soil to ameliorate passive heavy metals. Reducing the quantity of fertilizer and pesticide to control pollution. A number of key counties (cities) will be selected with 10 demonstration areas each covering about 5 thousand mu (333.33 ha) or more in each key county to modify local practices of chemical fertilizer and pesticide application. Preventing and controlling white pollution. Enhance and protect soil fertility: <ul style="list-style-type: none"> Crop straw returned to the soil. Applying organic fertilizers. Planting green manure and returning it to the soil.

	<p>4. Reduce the use of topsoil from cultivated land transferred for other purposes (e.g. built-up areas).</p> <p>5. Survey, monitor, and evaluate the quality of cultivated land:</p> <ul style="list-style-type: none"> • Construct a monitoring network of cultivated land quality. • Establish a big data platform for evaluating cultivated land quality. • Investigate and evaluate cultivated land quality.
Performance to-date	<p>At the end of 2015, \$0.84 billion (2015 USD) has been invested under this program²⁹⁰:</p> <ul style="list-style-type: none"> • \$ 127.33 million for cultivated land quality protection. • \$ 111.41 million for soil fertilizer testing and fertilizing. • \$ 79.58 million for black soil protection in northeast China. • \$ 238.74 million for heavy metal pollution control in Hunan province. <p>\$286.49 million for groundwater overdraft, agronomic water saving and restructuring in Hebei province.</p>
Unintended consequences	This program launched at the end of 2015 and no negative impacts have been reported.
Monitoring	<p>The Ministry of Agriculture establishes the Action Steering Group to verify the implementation of on-ground works. Corresponding agencies are also to be established in the agricultural sector in each province to supervise and inspect works conducted under the program.</p> <p>Experts will be engaged to conduct on-site inspections of program works sites.</p>
Level of community engagement	The program was launched at the end of 2015 and no statistical data has been reported.

Supplementary Table 17. Data sources used in quantifying the planned and actual area and investment for each of the 16 major sustainability programs.

Program names	Data	Year	Sources
1. Shelterbelt Development Program – Three North	Planned area and investment	1978–2050	State Forestry Administration program profile report ¹⁵⁹ .
		1978–1985	State Forestry Administration Phase 1 planning report ¹⁶⁰ .
		1986–1995	State Forestry Administration Phase 2 planning report ¹⁶¹ .
		1996–2000	State Forestry Administration Phase 3 planning report ¹⁶² .
		2001–2010	State Forestry Administration Phase 4 planning report ¹⁶³ and overview report ¹⁶⁸ .
		2011–2020	State Forestry Administration Phase 5 planning report ¹⁶⁴ .
	Actual area and investment	1978–1997	State Forestry Administration report ¹⁶⁷ .
		1998–2015	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ .
	Planned area and investment	1983–2007	Ministry of Water Resources website ¹⁷³ .
		2008–2012	Journal paper <i>China Water Resources</i> ¹⁷⁴ .
		2013–2015	Ministry of Water Resources program planning report ¹⁷⁵ .
	Actual investment	1983–2007	Ministry of Water Resources website ¹⁷³ .
		2008–2012	Journal paper <i>China Water Resources</i> ¹⁷⁴ and Ministry of Water Resources website ¹⁷³ .
	Actual area	1983–2002	Journal paper <i>Soil and Water Conservation in China</i> ²⁹¹ .
		2003–2007	Journal paper <i>Soil and Water Conservation in China</i> ¹⁷⁷ .
		2008–2012	Journal paper <i>China Water Resources</i> ¹⁷⁴ .
	Actual area and investment	2013–2015	Ministry of Water Resources program planning report ¹⁷⁵ .
3. Shelterbelt Development Program – Five Regions	Planned area and investment	2001–2010	UN Forum on Forests review paper ¹⁸¹ and Li (2005) report ¹⁸⁰ .
		2011–2020	State Forestry Administration program planning reports ^{184–187} .
	Actual area and investment	1989–1997	State Forestry Administration website ¹⁸⁸ . Notes: does not including The Plain Greening; area data refers to tree plantations only.
		1998–2015	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ . Note: area data includes trees plantations, mountain closure, and low-yielding forest improvement.
4. Comprehensive Agricultural Development Program	Planned area and investment	1988–2014	No information.
	Actual area and investment	1988–2015	Finance Yearbook of China ¹⁹⁴ .
5. Soil and Water Conservation Program – Yangtze	Planned investment	1989–2008	Journal paper, <i>Yangtze River</i> ²⁰⁷ .
	Actual area and investment	1989–2001	Journal paper, <i>Soil and Water Conservation in China</i> ²⁰⁶ .
		2002–2008	Journal papers, <i>Yangtze River</i> ⁵² and <i>Soil and Water Conservation in China</i> ²⁰⁶ .
		2009–2015	No data was available. We used the average annual treatment area from 1989 to 2008 ^{52,206} to estimate the actual area for the years 2009 to 2015. We estimated the actual investment based on the investment intensity from 2009 to 2015 projected to be 12,000 yuan km ⁻² based on ref ²⁰⁷ , which was multiplied by area to estimate the actual investment.
6. National Land Consolidation Program	Planned area and investment	2001–2010	Ministry of Land and Resources program planning report ²¹⁰ .
		2011–2015	Ministry of Land and Resources program planning report ²¹¹ .
	Actual area and investment	1999–2014	Ministry of Land and Resources China Land and Resources Statistical Yearbook ²¹⁴ .
		2015	Values estimated using linear trend based on the total investment and area from 1999 to 2014.
7. Natural Forest Conservation Program	Planned area and investment	2001–2010	Newspaper report, <i>People's Daily</i> ²²¹ .
		2011–2020	State Forestry Administration ²²² .
	Actual area and investment	1998–2015	China Forestry Statistical Yearbook ¹⁷¹ .
8. Grain for Green Program	Planned area and investment	1999–2010	State Forestry Administration program planning report ²²⁷ .
		2014–2020	Ministry of Finance program expansion notice ²³⁰ .
	Actual area and investment	1999–2015	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ .
9. Fast-growing and High-yielding Timber Program	Planned area and investment	2001–2015	State Forestry Administration program planning report ²⁴² .
	Actual area and investment	2001–2011	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ . Note: the project stalled between 2012 and 2015 due to implementation problems.
10. Forest Ecosystem Compensation Fund	Planned area and investment	2001–2015	Journal paper, <i>Forest Resources Management</i> ²⁵² .
	Actual area and investment	2001–2003	Journal paper, <i>Forest Resources Management</i> ²⁵² .
		2004	Journal paper, <i>Green Finance and Accounting</i> ²⁹² , Chongqing University

			thesis ²⁹³ .
		2007	Journal paper, <i>Forest Economics</i> ²⁵¹ .
		2008	Journal paper, <i>State Academy of Forestry Administration Journal</i> ²⁵⁴ .
		2009	Journal paper, <i>Forest Resources Management</i> ²⁵² .
		2011	Online article, <i>vicai.com</i> ²⁹⁴ .
		2013	Xinhua News article republished on PRC Central Government website ²⁹⁵ .
		2014	Xinhua News article ²⁵³ .
	Actual Investment	2005–2006	No information, values were estimated. We deduced that investment in these two years totalled 5 billion yuan ²⁵¹ , and the central government invested 2 billion yuan in 2004 ²⁹² , so we projected 2 billion yuan in 2005 and 3 billion yuan in 2006.
		2010	Online article, <i>vicai.com</i> ²⁹⁴ .
		2015	No information, values were estimated based on the average growth over the previous five years.
	Actual area	2005–2006	No information. Area was estimated based on the total amount of compensation and standard compensation rates per unit area.
		2010	No information. Area was estimated as the average of 2009 and 2011.
		2012	No information. Area was estimated as the average of 2011 and 2013.
		2015	No information. Area was estimated based on a linear projection of increases over the previous 5 years.
11. Sandification Control Program – Beijing/Tianjin	Planned area and investment	2001–2012	State Forestry Administration program planning report ²⁵⁷ .
		2013–2015	Baidu Wiki page ²⁹⁶ .
	Actual area and investment	1993–2015	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ .
12. Wildlife Conservation and Nature Protection Program	Planned area and investment	2001–2030	State Forestry Administration program planning report ²⁵⁹ .
	Actual area and investment	2001–2015	State Forestry Administration China Forestry Statistical Yearbook ¹⁷¹ .
13. Partnership to Combat Land Degradation	Planned and actual investment	2003–2012	Journal paper, <i>Land Degradation and Development</i> ²⁶⁶
		2013–2015	Steering Committee of PRC-GEF Partnership strategy report ²⁶⁵
	Actual area	2003–2015	Steering Committee of PRC-GEF Partnership strategy report ²⁶⁵
14. Rocky Desertification Treatment Program	Planned and actual investment	2008–2015	Development and Reform Commission program planning report ²⁷⁰ ; China Meteorological Administration website ²⁷⁴ ; summary report ²⁹⁷ ; news report published on Ministry of Land Resources website ²⁷³ ; news report published on ChinaNews website ²⁹⁸ ; news report published on Sohu website ²⁹⁹ .
	Planned and actual area	2008–2015	Development and Reform Commission program planning report ²⁷⁰ .
15. Grassland Ecological Protection Program	Planned and actual investment	2011–2015	News article published on People Network website ²⁷⁹ and paper, <i>Sichuan Animal and Veterinary Sciences</i> ²⁸³ .
	Planned and actual area	2011–2015	China Agriculture University thesis ²⁸⁴ .
16. Cultivated Land Quality Program	Planned area and investment	2015	Ministry of Agriculture program planning report ²⁸⁹
	Actual area and investment	2015	No information

Supplementary Table 18. Rationale underpinning the allocation of net weights estimating the level investment in each of the 17 SDGs under each of China's 16 sustainability programs. Trade-offs are bold text and the negative impact on net weight is shown in the calculation.

SDG	Explanation	Net weight	Investment (Million USD 2015)
Program 1: The Three-North Shelterbelt Development Program (三北防护林体系建设工程)			
SDG 1 No Poverty	This program contributed to Target 1.1 ' <i>eradicate extreme poverty for all people everywhere...</i> ', because from the second Phase, lifting farmers out of poverty was also considered as one of priorities in this program. The development of economic forest helped lift local farmers out of poverty. This program contributed to Target 1.5 ' <i>...build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events...</i> '	0.25	2085.38
SDG 2 Zero Hunger	One of the initial purposes of this program was to promote agricultural output in the Three-North region and maintain food security. Establishing farmland protection forest (such as windbreaks) was considered as a primary task in the early phases of this program. This program contributed to Target 6.6 ' <i>ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality</i> '.	0.20	1668.30
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 ' <i>substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination</i> ', as the built shelterbelt forests mitigated dust storms.	0.20	1668.30
SDG 6 Clean Water and Sanitation	Actions in this program, such as afforestation, reforestation, and mountain closure, contributed to Target 6.6 ' <i>protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes</i> '. However, in some regions, large-scale plantations in this program lowered groundwater tables and intensified water stress.	0.20 – 0.02 (negative) = 0.18	1501.47
SDG 7 Affordable and Clean Energy	Planted firewood forests as a renewable energy source contributed to Target 7.2 ' <i>increase substantially the share of renewable energy in the global energy mix</i> '.	0.01	83.42
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 ' <i>substantially reduce the proportion of youth not in employment, education or training</i> ' as it created job opportunities, such as afforestation and forest management jobs, as well as trained people as afforestation and forest management professionals.	0.15	1251.23
SDG 11 Sustainable Cities and Communities	Planted shelter forests in this program contributed to Target 11.5 ' <i>...decrease the direct economic losses relative to global gross domestic product caused by disasters, ... with a focus on protecting the poor and people in vulnerable situations</i> '	0.25	2085.38
SDG 12 Responsible Consumption and Production	This program contributed to Target 12.2 ' <i>achieve the sustainable management and efficient use of natural resources</i> ', as unsustainable livestock industries were stopped.	0.10	834.15
SDG 13 Climate Action	This program strongly contributed to ' <i>combat climate change and its impacts</i> ' via large-scale reforestation.	0.80	6673.21
SDG 15 Life on Land	This program mainly contributed to SDG15 (Targets 15.1, 15.2, 15.3, 15.4, 15.5, and 15.a) ' <i>Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</i> '	1.00	8341.51
Program 2: National Key Construction Program for Soil and Water (国家水土保持重点建设工程)			
SDG 1 No Poverty	This program was mainly carried out in poor regions and one of purposes of this program is to promote the adjustment of agricultural industrial structure and the economic development in the underdeveloped regions.	0.35	606.55
SDG 2 Zero Hunger	This program contributed to Targets 2.3 (' <i>double the agricultural productivity and incomes of small-scale food producers</i> '), 2.4 (ensure sustainable food production systems and increase agricultural productivity and production), and 2.a (' <i>enhance agricultural productive capacity in developing countries</i> ') .	0.20	346.60
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 ' <i>substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination</i> ', as the program reduced water sediment, thereby improved water quality and reduced	0.20	346.60

	the number of deaths and illnesses due to water quality.		
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (substantially increase agricultural water-use efficiency) and 6.6 ('protect and restore water-related ecosystems').	0.50	866.50
SDG 9 Industry, Innovation, and Infrastructure	This program contributed to Targets 9.1 'develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being'.	0.20	346.60
SDG 10 Reduced Inequalities	This program contributed to Targets 10.1 (increase economic growth in poor regions) and 10.4 (adopt policies to promote the development of poor regions).	0.80	1386.40
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 '...decrease the direct economic losses relative to global gross domestic product caused by disasters, ... with a focus on protecting the poor and people in vulnerable situations'.	0.60	1039.80
SDG 13 Climate Action	This program contributed to 'combat climate change and its impacts'.	0.20	346.60
SDG 15 Life on Land	This program contributed to SDG15 (Targets 15.1, 15.2, 15.3, 15.4, and 15.a) 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.	1.00	1733.00

Program 3: The Shelterbelt Development Program in Five Regions including the Middle and Lower Reaches of the Yangtze River (长江中下游地区等防护林体系建设工程)

SDG 1 No Poverty	This program contributed to Target 1.1 'eradicate extreme poverty for all people everywhere...' (For example, the development of economic forest is helpful to lift local farmers out of poverty). This program contributed to Target 1.5 ('build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters'). This program increased local revenue significantly. However, rehabilitated areas in this program were often destroyed by local people because government funding was neither sufficient nor stable. With inadequate economic incentives for participation, and local needs often ignored, the sustainability of restored areas was at risk.	0.25 – 0.02 (negative) = 0.23	1950.75
SDG 2 Zero Hunger	This program contributed to Target 2.4 'ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters'. Specially, windbreaks built in this program strengthened food production system's capacity for adaptation to extreme climates.	0.20	1696.31
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.6 'protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes'.	0.20	1696.31
SDG 7 Affordable and Clean Energy	Planted firewood forests as a renewable energy source contributed to Target 7.2 'increase substantially the share of renewable energy in the global energy mix'.	0.01	84.82
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 'substantially reduce the proportion of youth not in employment, education or training' as it created job opportunities, such as afforestation and forest management jobs, as well as trained people as afforestation and forest management professionals.	0.15	1272.23
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 '...decrease the direct economic losses relative to global gross domestic product caused by disasters, ... with a focus on protecting the poor and people in vulnerable situations'.	0.80	6785.23
SDG 13 Climate Action	This program contributed to 'combat climate change and its impacts'.	0.80	6785.23
SDG 15 Life on Land	This program mainly contributed to SDG15 (Targets 15.1, 15.2, 15.3, 15.4, and 15.5) 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.	1.00	8481.53

Program 4: Comprehensive Agricultural Development Program (农业综合开发工程)

SDG 1 No Poverty	This program promoted the agricultural industrialization and increased the farmers' income.	0.40	56823.32
SDG 2 Zero Hunger	This program contributed to Targets 2.3 ('double the agricultural productivity and incomes of small-scale food producers'), 2.4 ('ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production'), and 2.a (Increase investment in rural infrastructure and technology)	0.50	71029.15

	development, and enhance agricultural productive capacity).		
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (canal water-saving transformation to improve the efficiency of agriculture water use) and 6.6 ('protect and restore water-related ecosystems').	0.05	7102.92
SDG 8 Decent Work and Economic Growth	This program contributed to Targets 8.2 (Agricultural industrialization projects to improve the agricultural productivity) and 8.3 (Support the development of agricultural industrialization and encourage the growth of agricultural enterprises).	0.30	42617.49
SDG 9 Industry, Innovation, and Infrastructure	This program contributed to Target 9.1 'develop quality, reliable, sustainable and resilient infrastructure'	0.15	21308.75
SDG 10 Reduced Inequalities	This program contributed to Target 10.1 'progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average', as this program promoted the development of agriculture and increased farmers' income. This program also contributed Target 10.4 'adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality'	0.20	28411.66
SDG 11 Sustainable Cities and Communities	Actions, such as small watershed governance and desertification control in this program contributed to Target 11.5 ('...decrease the direct economic losses relative to global gross domestic product caused by disasters').	0.30	42617.49
SDG 12 Responsible Consumption and Production	This program contributed to Targets 12.2 (agricultural industrialization supports efficient use of natural resources) and 12.3 (agricultural industrialization, such as storage and preservation, substantially reduced food waste).	0.20	28411.66
SDG 13 Climate Action	Actions, such as grassland construction in this program contributed to Target 13.1 ('strengthen resilience and adaptive capacity to climate-related hazards and natural disasters').	0.10	14205.83
SDG 15 Life on Land	This program contributed to Target 15.3 ('combat desertification, restore degraded land and soil').	0.50	71029.15

Program 5: Program of Soil and Water Conservation in Key Areas of the Upper Yangtze River

(长江上中游水土保持重点防治工程)

SDG 1 No Poverty	This program contributed to Target 1.1 (increase farmers' income by encouraging farmers to participate in program governance and plant economic forests).	0.15	238.86
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain agricultural ecosystem stability and improve agricultural productivity and production).	0.20	318.48
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 'substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination', as the program reduced water sediment, thereby improved water quality and reduced the number of deaths and illnesses due to water quality.	0.20	318.48
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (improve the efficiency of agriculture water use) and 6.6 ('protect and restore water-related ecosystems').	0.90	1433.15
SDG 10 Reduced Inequalities	This program contributed to Target 10.1 (achieve income growth of farmers in poor regions through the program governance).	0.50	796.19
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 ('...decrease the direct economic losses relative to global gross domestic product caused by disasters', particularly in rural areas).	0.60	955.43
SDG 13 Climate Action	This program contributed to Target 13.1 ('strengthen resilience and adaptive capacity to climate-related hazards and natural disasters').	0.20	318.48
SDG 15 Life on Land	This program mainly contributed to SDG 15 (Targets 15.1, 15.2, 15.3, 15.4, 15.5, and 15.a) 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'. The scope of this program included poor areas where part of the population was still in poverty. Focusing on ecological and social benefits while ignoring the development of the rural economy and growth of farmers' income restricted the program implementation in these areas.	1.00 – 0.10 (negative) = 0.90	1433.15

Program 6: National Land Consolidation Program (国家土地整治工程)

SDG 1 No Poverty	This program contributed to Targets 1.1 (increase farmers' income by improving land productivity) and 1.5 ('build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters').	0.60	45700.30
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain ecosystem stability, adapt to climate	1.00	76167.17

Hunger	changes, improve agricultural productivity and production, and raise food security).		
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.4 (substantially increase agricultural water-use efficiency and reduce the number of people suffering from water scarcity).	0.10	7616.72
SDG 8 Decent Work and Economic Growth	This program contributed to Targets 8.2 ' <i>achieve higher levels of economic productivity through diversification, technological upgrading and innovation</i> ' and 8.6 ' <i>substantially reduce the proportion of youth not in employment, education or training</i> ' by creating project implementation jobs and training implementation staff.	0.20	15233.43
SDG 9 Industry, Innovation, and Infrastructure	This program contributed to Target 9.1 ' <i>develop quality, reliable, sustainable and resilient infrastructure</i> ' for the development of agricultural economy.	0.15	11425.08
SDG 10 Reduced Inequalities	This program contributed to Target 10.1 (achieve income growth of farmers in poor regions through program governance).	0.30	22850.15
SDG 11 Sustainable Cities and Communities	The consolidation of rural construction land contributed to Target 11.3 (enhance capacity for participatory, integrated and sustainable human settlement planning and management). This program also contributed to Target 11.5 (' <i>significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations</i> '').	0.20	15233.43
SDG 12 Responsible Consumption and Production	This program contributed to Target 12.2 ' <i>achieve the sustainable management and efficient use of natural resources</i> '.	0.20	15233.43
SDG 13 Climate Action	This program contributed to Target 13.1 (' <i>strengthen resilience and adaptive capacity to climate-related hazards and natural disasters</i> '').	0.15	11425.08
SDG 15 Life on Land	This program contributed to Target 15.3 (combat desertification, and restore degraded land and soil). This program might negatively contribute to Target 15.5 in some regions. This program decreased ecosystem service value in some places (due to ecosystem service loss of wetlands and grasslands) and changed the ecological connectivity as well as the land-use structure in some regions.	0.90 – 0.15 (negative) = 0.75	57125.38

Program 7: Natural Forest Conservation Program (天然林保护工程)

SDG 1 No Poverty	This program also negatively contributed to Target 1.1 (planted timber forests and economic forests increased the income of related personnel). This program also negatively contributed to Target 1.1 at the early implementation phase. The implementation scheme of the 1st Phase was criticized as being inconsistent with economic development goals as it led to declines in revenues to local governments, industries, and forestry workers. The central government modified the policy for the 2nd Phase in an effort to address this problem.	0.10 – 0.05 = 0.05	1751.78
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain ecosystem stability, adapt to climate changes, improve agricultural productivity and production, and promote sustainable agriculture).	0.10	3503.56
SDG 6 Clean Water and Sanitation	Actions in this program, such as afforestation, reforestation, and mountain closure, contributed to Target 6.6 ' <i>protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes</i> '.	0.45	15766.02
SDG 7 Affordable and Clean Energy	Planted firewood forests as a renewable energy source contributed to Target 7.2 ' <i>increase substantially the share of renewable energy in the global energy mix</i> '.	0.01	350.36
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 ' <i>substantially reduce the proportion of youth not in employment, education or training</i> ' as it created job opportunities, such as afforestation and forest management jobs, as well as trained people as afforestation and forest management professionals.	0.15	5255.34
SDG 10 Reduced Inequalities	This program contributed to Targets 10.1 ' <i>progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average</i> ' and 10.3 ' <i>ensure equal opportunity and reduce inequalities of outcome</i> '	0.20	7007.12
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 (' <i>significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations</i> '').	0.80	28028.48
SDG 13 Climate Action	This program contributed to Targets 13.1 (' <i>strengthen resilience and adaptive capacity to climate-related hazards and natural disasters</i> '') and 13.3 (' <i>Improve education, awareness-raising and human and institutional capacity on climate change mitigation,</i>	1.00	35035.59

	<i>adaptation, impact reduction and early warning').</i>		
SDG 15 Life on Land	This program mainly contributed to SDG15 (Targets 15.1, 15.2, 15.3, 15.4, 15.5, and 15.a) ' <i>Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</i> '.	1.00	35035.59

Program 8: Grain for Green Program (退耕还林工程)

SDG 1 No Poverty	This program contributed to Target 1.1 (increased farmers' income in poor areas through government subsidies and economic forest plantation).	0.40	21828.20
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain ecosystem stability, adapt to climate changes, improve agricultural productivity and production, and promote sustainable agriculture) particularly through large-scale planting of economic forests.	0.20	10914.10
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 ' <i>substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination</i> ', as the program reduced water sediment, thereby improved water quality and reduced the number of deaths and illnesses due to water quality.	0.10	5457.05
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.6 ' <i>protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes</i> '. However, vegetation was degraded in arid and semi-arid areas because of reduced soil water availability and mismanagement of planted vegetation. Also, expansion of forest areas caused significant declines in downstream flows in the Yellow and the Yangtze Rivers, which created a tension with increased water demand for growing populations and industrial and agricultural production activities.	0.55 – 0.05 = 0.50	27285.25
SDG 7 Affordable and Clean Energy	Planted firewood forests as a renewable energy source contributed to Target 7.2 ' <i>increase substantially the share of renewable energy in the global energy mix</i> '.	0.01	545.70
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 ' <i>substantially reduce the proportion of youth not in employment, education or training</i> ' as it created job opportunities, such as afforestation and forest management jobs, as well as trained people as afforestation and forest management professionals.	0.15	8185.57
SDG 10 Reduced Inequalities	This program contributed to Targets 10.1 ' <i>progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average</i> ' and 10.3 ' <i>ensure equal opportunity and reduce inequalities of outcome</i> '	0.20	10914.10
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 (' <i>significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations</i> '')	0.80	43656.39
SDG 13 Climate Action	This program contributed to Target 13.1 (' <i>strengthen resilience and adaptive capacity to climate-related hazards and natural disasters</i> ') and 13.3 (' <i>Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning</i> '')	0.80	43656.39
SDG 15 Life on Land	This program contributed to Targets 15.1 (' <i>ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services</i> ') and 15.2 (' <i>promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation</i> '). This program also contributed to Targets 15.4 (' <i>ensure the conservation of mountain ecosystems, including their biodiversity</i> ') and 15.5 (' <i>take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, protect and prevent the extinction of threatened species</i> '). However, monocultures or simple mixed forests overwhelmingly dominate Grain for Green forests. This program also resulted in major losses of bird and bee diversity.	1.00 – 0.1 = 0.90	49113.44

Program 9: Program of the Base Construction of Fast-Growing and High-Yielding Timber Forest

(重点地区速生丰产用材林基地建设工程)

SDG 2 Zero Hunger	This program negatively contributed to Target 2.1 as the fast-growing and high-yielding timber plantations in southern China led to concerns around depleting soil nutrients and groundwater resources, and creating competition with agricultural crops for water and high-quality land.	-0.15	-45.34
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.6 ' <i>protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes</i> '. However, in some regions, the fast-growing and high-yielding timber plantations might deplete soil nutrients and groundwater resources.	0.10 – 0.05 = 0.05	15.11
SDG 8 Decent Work and Economic Growth	This program contributed to Targets 8.2 (achieve higher levels of forestry productivity through diversification, technological upgrading and innovation) and 8.3 (' <i>encourage the formalization and growth of micro-, small- and medium-sized enterprises</i> ').	0.20	60.46

SDG 9 Industry, Innovation, and Infrastructure	This program contributed to Target 9.3 ('Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets').	0.20	60.46
SDG 12 Responsible Consumption and Production	This program contributed to Target 12.2 ('achieve the sustainable management and efficient use of natural resources').	0.20	60.46
SDG 15 Life on Land	This program contributed to Target 15.2 ('promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation').	1.00	302.28

Program 10: Central Government Forest Ecosystem Compensation Fund Program (中央财政森林生态效益补偿基金工程)

SDG 1 No Poverty	This program contributed to Target 1.1 (compensation fund increased farmers' income).	1.00	16121.99
SDG 6 Clean Water and Sanitation	Forest management in this program contributed to Target 6.6 'protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes'.	0.45	7254.89
SDG 10 Reduced Inequalities	This program contributed to Targets 10.3 (reduce inequalities that maintaining ecosystems has no economic benefit through compensation) and 10.4 (adopt policies to progressively achieve greater equality). However, this program also faced some problems including low levels of compensation, incomplete coverage of compensation, and compensation did not increase in-line with economic development.	0.80	12897.59
SDG 13 Climate Action	This program contributed to Target 13.1 ('strengthen resilience and adaptive capacity to climate-related hazards and natural disasters').	0.60	9673.19
SDG 15 Life on Land	This program contributed to Targets 15.1 (ensure the conservation, restoration and sustainable use of terrestrial ecosystems and their services), 15.2 (promote the implementation of forest sustainable management and halt deforestation), 15.4 ('ensure the conservation of mountain ecosystems, including their biodiversity'), and 15.5 ('take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, protect and prevent the extinction of threatened species').	1.00	16121.99

Program 11: The Sandification Control Program for Areas in the Vicinity of Beijing and Tianjin (津京风沙源治理工程)

SDG 1 No Poverty	This program contributed to Target 1.1 (A small amount of planted economic forests contributed to the increase of farmers' income).	0.01	79.46
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain agricultural ecosystems and strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality).	0.20	1589.26
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 'substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination', as the built shelterbelt forests mitigated dust storms.	0.20	1589.26
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (small watershed water source projects substantially increased water-use efficiency and substantially reduced the number of people suffering from water scarcity) and 6.6 ('protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes'). However, the tree species planted in arid and semi-arid areas in this program consumed more water than native plants. The planted trees did not adapt to local arid and semi-arid conditions, and could largely die if irrigated water supply (mainly using groundwater resources) stopped.	0.20 – 0.05 = 0.15	1191.94
SDG 7 Affordable and Clean Energy	Planted firewood forests as a renewable energy source contributed to Target 7.2 'increase substantially the share of renewable energy in the global energy mix'.	0.05	397.31
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 'substantially reduce the proportion of youth not in employment, education or training' as it created job opportunities, such as afforestation and forest management jobs, as well as trained people as afforestation and forest management professionals.	0.15	1191.94
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 ('significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations').	0.80	6357.04
SDG 13 Climate Action	This program contributed to Targets 13.1 ('strengthen resilience and adaptive capacity to climate-related hazards and natural disasters') and 13.2 ('Integrate climate change measures into national policies, strategies and planning')	1.00	7946.30
SDG 15 Life on Land	This program contributed to Targets 15.1 (ensure the conservation, restoration and sustainable use of terrestrial ecosystems and their services), 15.2 (promote the implementation of forest sustainable management and halt deforestation), 15.3 (combat	1.00 – 0.10 = 0.90	7151.67

	desertification, and restore degraded land and soil), and 15.4 (ensure the conservation of mountain ecosystems). However, monoclonal plantations lacked diversity and had great potential risk to be seriously damaged by pests and diseases.		
Program 12: The Wildlife Conservation and Nature Reserve Protection Program (野生动植物保护及自然保护区建设工程)			
SDG 1 No Poverty	This program negatively affected the achievement of this SDG, as nature reserves identified in this program were mostly in remote and poor areas, and the contradiction between poverty elimination and ecological protection was dominant. Ongoing economic development in nature reserves resulted in the fragmentation of ecosystems and degraded their ecological function.	-0.02	-48.03
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.6 'protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes'.	0.30	720.51
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.4 ('protect and safeguard the world's cultural and natural heritage').	0.20	480.34
SDG 15 Life on Land	This program contributed to Targets 15.1 ('ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services'), 15.4 ('ensure the conservation of mountain ecosystems, including their biodiversity'), 15.5 ('Take urgent and significant action to reduce the degradation of natural habitats, and halt the loss of biodiversity'), and 15.7 ('Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products').	1.00	2401.71
Program 13: PRC-GEF Partnership to Combat Land Degradation in Dryland Ecosystems (中国-全球环境基金干旱生态系统土地退化防治伙伴关系)			
SDG 1 No Poverty	This program contributed to Target 1.1 (reduce poverty for people in western China).	0.80	6522.08
SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain agricultural ecosystems and strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality).	0.50	4076.30
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (substantially increase agricultural water-use efficiency and reduce the number of people suffering from water scarcity) and 6.a ('expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies').	0.30	2445.78
SDG 8 Decent Work and Economic Growth	This program contributed to Target 8.6 'substantially reduce the proportion of youth not in employment, education or training' as it created job opportunities, such as forest management jobs, as well as trained people as forest management professionals.	0.15	1222.89
SDG 10 Reduced Inequalities	This program contributed to Targets 10.1 (progressively achieve and sustain income growth of the population in western China).	0.50	4076.30
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 ('significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations').	0.80	6522.08
SDG 13 Climate Action	This program contributed to Targets 13.1 ('strengthen resilience and adaptive capacity to climate-related hazards and natural disasters') and 13.3 ('Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning').	0.80	6522.08
SDG 15 Life on Land	This program contributed to Targets 15.2 (restore degraded forests and substantially increase afforestation and reforestation), 15.3 (combat desertification, and restore degraded land and soil), and 15.4 (ensure the conservation of mountain ecosystems, including their biodiversity).	1.00	8152.60
SDG 17 Partnerships for the Goals	This program contributed to SDG17 ('Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development'). However, the implementation of this program through the Integrated Ecosystem Management approach has been hindered by inherent coordination difficulties within the partnership.	1.00 – 0.05 = 0.95	7744.97
Program 14: Rocky Desertification Comprehensive Treatment Program in Karst Area (岩溶地区石漠化综合治理工程)			
SDG 1 No Poverty	This program contributed to Target 1.1 (increase farmers' income in poor areas through the governance).	0.40	793.72

SDG 2 Zero Hunger	This program contributed to Target 2.4 (Maintain agricultural ecosystems, increase agricultural productivity and production, strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality).	0.20	396.86
SDG 6 Clean Water and Sanitation	This program contributed to Targets 6.4 (improve the efficiency of agriculture water use — a key effort in this program is to solve the water conservation issue in rocky desertification areas and to reduce the number of people who suffered from water shortage.) and 6.6 ('protect and restore water-related ecosystems').	0.50	992.15
SDG 7 Affordable and Clean Energy	The construction of biogas pools as a renewable energy source contributed to Target 7.2 ' <i>increase substantially the share of renewable energy in the global energy mix</i> '. However, the newly built biogas digesters did not receive proper maintenance.	0.20 – 0.05 = 0.15	297.65
SDG 10 Reduced Inequalities	This program contributed to Target 10.1 (improved backward economy in rocky desertification areas).	0.50	992.15
SDG 13 Climate Action	This program contributed to Target 13.1 (' <i>strengthen resilience and adaptive capacity to climate-related hazards and natural disasters</i> ').	0.20	396.86
SDG 15 Life on Land	This program contributed to Targets 15.2 (restore degraded forests and substantially increase afforestation and reforestation), 15.3 (combat desertification, and restore degraded land and soil), and 15.4 (ensure the conservation of mountain ecosystems, including their biodiversity). However, the maintenance of planted forests did not reach predesigned requirements.	0.80 – 0.05 = 0.75	1488.23

Program 15: The Grassland Ecological Protection Subsidies and Awards Program (草原生态保护补助奖励项目)

SDG 1 No Poverty	This program contributed to Target 1.1 (subsidies and awards increased herders' income).	1.00	12761.95
SDG 2 Zero Hunger	This program contributed to Target 2.4 (pasture recuperation supported sustainable grassland farming).	0.30	3828.59
SDG 8 Decent Work and Economic Growth	This program contributed to Targets 8.2 (upgraded the animal husbandry industry and improved the economic productivity by using pastures by turns) and 8.4 (decoupled economic growth from environmental degradation by improving the pasture resources use efficiency)	0.15	1914.29
SDG 10 Reduced Inequalities	This program contributed to Target 10.1 (increased herders' income). However, due to the lack of precision in subsidy standards and lack of a scientific basis particularly with regard to adaptation to local conditions, some subsidies and awards have been excessive in some areas while inadequate in other areas. This has produced inequality and conflict in the course of program implementation.	0.90 – 0.10 = 0.80	10209.56
SDG 12 Responsible Consumption and Production	This program contributed to Target 12.2 (sustainable management and efficient use of pasture resources).	0.80	10209.56
SDG 13 Climate Action	This program contributed to Target 13.1 (strengthen rangeland's resilience and adaptive capacity to climate-related hazards and natural disasters).	1.00	12761.95
SDG 15 Life on Land	This program contributed to Targets 15.1 (ensure the conservation, restoration and sustainable use of terrestrial ecosystems and their services) and 15.3 (combat desertification, and restore degraded land and soil).	1.00	12761.95

Program 16: Cultivated Land Quality Protection and Promotion Program (耕地质量保护与提升工程)

SDG 2 Zero Hunger	This program contributed to Targets 2.1 (soil pollution control improve food security) and 2.4 (cultivated land quality promotion ensures sustainable food production systems).	0.50	421.77
SDG 3 Good Health and Well-being	This program contributed to Target 3.9 (substantially reduce the number of deaths and illnesses from hazardous soil contamination)	0.40	337.42
SDG 6 Clean Water and Sanitation	This program contributed to Target 6.3 (improve water quality by reducing agricultural non-point source pollution)	0.30	253.06
SDG 8 Decent Work and Economic Growth	This program contributed to Targets 8.2 (protected cultivated land quality and increased the productivity of the agricultural economy through agricultural engineering technology upgrading and innovative agronomic measures) and 8.4 (decoupled economic growth from environmental degradation)	0.15	126.53

SDG 9 Industry, Innovation, and Infrastructure	This program contributed to Target 9.1 ' <i>develop quality, reliable, sustainable and resilient infrastructure</i> ' for the development of agricultural economy.	0.10	84.35
SDG 10 Reduced Inequalities	This program contributed to Targets 10.1 ' <i>progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average</i> ' and 10.3 ' <i>ensure equal opportunity and reduce inequalities of outcome</i> '	0.20	168.71
SDG 11 Sustainable Cities and Communities	This program contributed to Target 11.5 ' <i>significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations</i> '	0.15	126.53
SDG 12 Responsible Consumption and Production	This program contributed to Targets 12.2 (achieve the sustainable management of cultivated land resources) and 12.5 (substantially reduce waste generation).	0.40	337.42
SDG 15 Life on Land	This program contributed to Target 15.3 (restore degraded land and soil)	0.50	421.77

Supplementary Table 19. Total value of investment by province. Total value of investment (in millions 2015 USD) in sustainability interventions from 1978 to 2015 under the 16 major sustainability programs by province/autonomous region. Note that no provincial-level breakdown had been reported for P16 as it only began in late 2015, hence we distributed P16 investment evenly across provinces as an approximation. Source data is presented in Supplementary Data 1.

Province/ Autonomous Region	P1 Shelterbelt Development Program – Three North	P2 Soil and Water Conservation Program – National	P3 Shelterbelt Development Program – Five Regions	P4 Comprehensive Agricultural Development Program	P5 Soil and Water Conservation Program – Yangtze	P6 National Land Consolidation Program	P7 Natural Forest Conservation Program	P8 Grain for Green Program	P9 Fast-growing and High-yielding Timber Program	P10 Forest Ecosystem Compensation Fund	P11 Sandification Control Program – Beijing/Tianjin	P12 Wildlife Conservation and Nature Protection Program	P13 Partnership to Combat Land Degradation	P14 Rocky Desertification Treatment Program	P15 Grassland Ecological Protection Program	P16 Cultivated Land Quality Program	Total
Beijing	401	105	1,743	2,104	0	649	0	2	0	37	695	43	0	0	0	27	5,807
Tianjin	479	610	1,776	0	426	0	1	0	1	1	68	15	0	0	0	27	3,404
Hebei	725	162	413	6,828	0	2,189	0	1,291	33	310	2,678	61	0	0	0	27	14,716
Shanxi	395	175	138	3,346	0	1,713	734	2,291	1	256	1,094	41	231	0	0	27	10,443
Inner Mongolia	1,333	136	1	6,239	0	919	4,888	3,046	0	1,822	3,388	96	567	0	4,065	27	26,528
Liaoning	390	131	325	8,677	0	2,803	347	1,262	0	432	0	42	0	0	0	27	14,436
Jilin	322	1	6,134	0	663	2,850	1,053	11	442	0	82	0	0	0	0	27	11,584
Heilongjiang	670	0	9,723	0	2,037	10,638	1,576	15	1,045	0	144	0	0	0	0	27	25,875
Shanghai	0	391	1,072	0	1,700	0	0	4	0	0	0	135	0	0	0	27	3,329
Jiangsu	0	1,253	7,145	0	5,136	0	0	4	8	0	62	0	0	0	0	27	13,635
Zhejiang	0	499	6,717	0	10,652	0	0	0	0	168	0	33	0	0	0	27	18,097
Anhui	0	74	189	5,525	0	2,080	0	1,300	8	212	0	39	0	0	0	27	9,453
Fujian	0	86	214	3,776	0	1,385	0	0	53	267	0	93	0	0	0	27	5,902
Jiangxi	0	180	208	4,930	139	1,374	0	1,285	4	389	0	84	0	0	0	27	8,621
Shandong	0	76	816	8,150	0	5,978	0	0	24	173	0	41	0	0	0	27	15,286
Henan	0	76	229	7,594	139	4,016	202	1,640	16	145	0	34	0	0	0	27	14,118
Hubei	0	69	189	5,756	168	3,106	723	2,290	11	249	0	88	0	99	0	27	12,775
Hunan	0	31	186	6,373	139	5,309	0	3,144	35	722	0	153	0	99	0	27	16,218
Guangdong	0	444	3,006	0	4,025	0	0	6	170	0	90	0	20	0	27	7,788	
Guangxi	0	18	273	2,888	0	1,256	0	1,413	57	871	0	161	0	238	0	27	7,202
Hainan	0	13	99	1,875	0	247	226	231	2	78	0	57	0	0	0	27	2,855
Chongqing	0	16	0	2,957	168	1,663	842	4,045	3	155	0	35	0	99	0	27	10,009
Sichuan	0	47	0	6,477	168	6,513	5,007	8,468	0	1,827	0	137	1,739	99	730	27	31,239
Guizhou	0	21	112	2,422	168	2,017	1,066	3,582	8	385	0	47	1,151	1,091	0	27	12,098
Yunnan	0	117	3,854	168	1,891	2,289	2,985	5	890	0	123	0	238	246	27	12,833	
Tibet	0	18	1,004	0	47	206	115	0	1,184	0	174	0	0	2,465	27	5,241	
Shaanxi	385	175	12	3,883	168	1,573	2,085	4,594	0	739	23	54	514	0	0	27	14,234
Gansu	448	136	0	2,573	168	1,855	1,505	4,536	0	839	0	50	768	0	937	27	13,841
Qinghai	324	0	1,678	0	76	655	1,391	0	667	0	107	1,530	0	2,093	27	8,548	
Ningxia	288	8	0	1,928	0	562	222	1,406	0	80	0	35	1,108	0	246	27	5,910
Xinjiang	2,181	0	5,648	0	2,307	550	1,622	2	1,561	0	46	543	0	1,981	27	16,467	
Total	8,342	1,733	8,482	142,058	1,592	76,167	35,036	54,570	302	16,122	7,946	2,402	8,153	1,984	12,762	844	378,495

Supplementary Table 20. Total area of addressed by province. Total area (in thousands of hectares) of sustainability interventions under the 16 programs by province/autonomous region. Note that no area of sustainability interventions had been reported for P16 as it only began in late 2015. Source data is presented in Supplementary Data 2.

Province/ Autonomous Region	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	Total
Beijing	286	664	268	348	0	77	0	0	0	235	508	26	0	0	0	0	2,413
Tianjin	249	0	164	386	0	89	0	0	0	7	81	4	0	0	0	0	980
Hebei	3,888	805	2,568	2,962	0	653	0	1,198	30	1,734	3,679	205	0	0	0	0	17,723
Shanxi	3,256	838	1,645	897	0	227	1,035	1,756	1	1,614	1,046	125	238	0	0	0	12,678
Inner Mongolia	6,978	741	1	4,432	0	813	5,631	2,143	0	11,498	7,511	1,928	577	0	68,000	0	110,254
Liaoning	3,578	728	959	2,473	0	570	88	1,134	0	2,415	0	179	0	0	0	0	12,123
Jilin	1,572	0	2	2,685	0	365	2,843	1,004	0	2,787	0	637	0	0	0	0	11,896
Heilongjiang	4,291	0	19	5,285	0	1,373	5,148	1,452	6	5,841	0	2,168	0	0	0	0	25,584
Shanghai	0	0	62	160	0	100	407	7	0	0	0	3	0	0	0	0	738
Jiangsu	0	0	774	3,024	0	1,035	0	0	13	49	0	72	0	0	0	0	4,967
Zhejiang	0	0	1,161	1,496	0	845	0	0	0	937	0	19	0	0	0	0	4,458
Anhui	0	174	856	2,603	0	505	0	783	4	1,186	0	39	0	0	0	0	6,150
Fujian	0	205	902	975	0	312	0	20	8	1,495	0	92	0	0	0	0	4,009
Jiangxi	0	850	1,038	1,469	960	520	0	850	19	2,174	0	281	0	0	0	0	8,162
Shandong	0	181	1,619	4,169	0	1,562	0	0	2	970	0	143	0	0	0	0	8,647
Henan	0	181	1,603	3,308	960	1,165	212	1,325	13	915	0	102	0	0	0	0	9,783
Hubei	0	304	1,388	2,043	1,436	440	1,455	1,314	22	1,569	0	200	0	330	0	0	10,502
Hunan	0	77	902	2,115	960	894	0	1,597	35	4,036	0	333	0	330	0	0	11,279
Guangdong	0	0	1,198	816	0	260	0	0	5	1,070	0	367	0	66	0	0	3,781
Guangxi	0	45	988	1,160	0	309	0	1,253	20	4,871	0	120	0	792	0	0	9,558
Hainan	0	32	175	740	0	69	108	187	0	490	0	46	0	0	0	0	1,848
Chongqing	0	39	202	741	1,436	486	1,306	1,263	0	977	0	165	0	330	0	0	6,944
Sichuan	0	116	293	2,616	1,436	1,654	6,957	2,124	0	11,533	0	1,013	1,807	330	14,133	0	44,013
Guizhou	0	51	835	958	1,436	227	1,359	1,557	24	2,432	0	249	1,187	3,630	0	0	13,945
Yunnan	0	0	710	1,115	1,436	580	3,763	2,028	21	5,618	0	345	0	792	4,867	0	21,275
Tibet	0	0	366	497	0	15	192	180	0	7,475	0	6,366	0	0	69,067	0	84,158
Shaanxi	3,973	838	482	1,420	1,436	271	2,990	2,735	0	4,665	53	206	518	0	0	0	19,586
Gansu	3,298	741	103	730	1,436	444	1,353	2,132	0	5,293	0	975	762	0	16,067	0	33,335
Qinghai	2,043	0	58	1,288	0	30	653	815	0	4,210	0	3,413	1,602	0	31,600	0	45,712
Ningxia	2,061	19	0	582	0	194	602	950	0	507	0	53	1,086	0	2,400	0	8,454
Xinjiang	7,404	0	86	2,477	0	570	292	1,492	3	8,730	0	1,373	527	0	46,000	0	68,955
Total	42,877	7,630	21,429	55,968	12,933	16,652	36,394	31,300	227	97,334	12,878	21,250	8,304	6,600	252,133	0	623,910

Supplementary Table 21. Total area of interventions by province. Area (in thousands of hectares) of on-ground actions implemented from 1998–2014 under the 16 major sustainability programs. See Supplementary Fig. 1 for description of interventions. Source data is presented in Supplementary Data 3.

Province/ Autonomous Region	Timber forests	Economic forests	Protection forests	Fuelwood forests	Special use forests	Forest management	Wildlife conservation and nature reserves	Grassland plantation/management	Small watershed improvement	Land consolidation	Land development	Land reclamation	Improvement of low and medium-yield cropland	Demonstration of high-yield cropland	Desertification control	Soil and water conservation	Total
Beijing	14	47	281	0	19	463	26	28	166	38	18	13	179	10	0	295	1,599
Tianjin	28	18	80	13	0	53	4	1	7	46	31	2	201	47	0	0	531
Hebei	508	524	3,615	18	8	3,640	219	964	507	312	160	109	1,433	225	40	389	12,672
Shanxi	218	518	3,598	55	1	2,824	149	212	165	69	113	20	477	66	190	411	9,086
Inner Mongolia	229	239	8,522	18	12	16,887	1,959	71,154	440	495	104	124	1,159	264	469	347	102,418
Liaoning	227	167	1,587	46	2	3,425	179	100	92	392	71	43	1,289	234	3	338	8,194
Jilin	164	63	745	1	3	5,537	636	591	0	167	17	141	1,258	305	1	0	9,630
Heilongjiang	395	60	1,634	27	35	10,781	1,709	403	29	968	47	205	2,750	443	12	0	19,497
Shanghai	1	12	17	0	2	407	3	0	1	38	16	35	102	0	0	0	635
Jiangsu	29	14	252	0	0	67	73	2	5	462	162	295	1,687	260	6	0	3,314
Zhejiang	7	22	144	0	1	1,595	19	0	100	527	139	85	825	67	0	0	3,531
Anhui	72	131	695	2	3	1,404	38	49	83	275	79	95	1,467	154	0	148	4,694
Fujian	48	17	144	6	0	1,793	145	0	70	143	63	71	528	50	0	169	3,247
Jiangxi	257	78	616	3	2	2,571	176	51	57	284	107	71	755	150	0	1,164	6,342
Shandong	39	130	378	0	1	1,110	156	36	27	844	255	290	2,386	227	38	153	6,068
Henan	433	197	1,115	7	3	1,304	103	109	2	585	169	282	1,841	295	4	898	7,347
Hubei	429	224	1,156	30	5	3,220	209	4	3	212	139	40	1,157	163	272	792	8,053
Hunan	310	175	1,178	6	9	4,172	343	104	3	520	136	138	1,141	200	272	796	9,502
Guangdong	8	1	249	0	0	1,415	380	0	0	60	162	10	439	90	54	0	2,866
Guangxi	661	136	361	2	3	5,272	128	54	1	106	145	24	669	80	652	30	8,322
Hainan	42	31	167	0	2	572	48	10	2	30	10	22	459	18	0	21	1,433
Chongqing	222	174	1,308	12	0	1,818	45	54	83	308	38	86	359	58	272	771	5,608
Sichuan	478	312	4,306	11	4	14,925	1,013	14,411	10	1,242	66	161	1,381	150	1,633	822	40,924
Guizhou	182	173	1,667	9	5	3,567	251	113	7	71	112	19	552	59	3,937	779	11,503
Yunnan	427	831	1,697	28	3	8,259	318	4,923	40	259	191	66	611	79	652	745	19,127
Tibet	2	2	246	3	0	7,370	6,366	69,343	0	2	9	3	96	14	0	0	83,455
Shaanxi	429	618	4,237	51	2	6,385	444	220	47	79	103	59	791	86	424	1,156	15,132
Gansu	119	229	2,913	43	55	6,295	1,801	16,231	17	270	100	25	350	65	644	1,091	30,248
Qinghai	12	3	1,043	23	0	5,165	3,413	32,424	13	11	14	1	179	58	972	0	43,331
Ningxia	5	166	1,438	7	0	1,090	53	2,427	7	105	53	14	291	60	907	13	6,637
Xinjiang	69	985	1,768	31	4	10,092	1,292	46,259	2	205	248	53	1,285	137	563	0	62,994
Total	6,061	6,295	47,156	454	183	133,477	21,695	260,276	1,986	9,123	3,076	2,599	28,096	4,114	12,019	11,329	547,941

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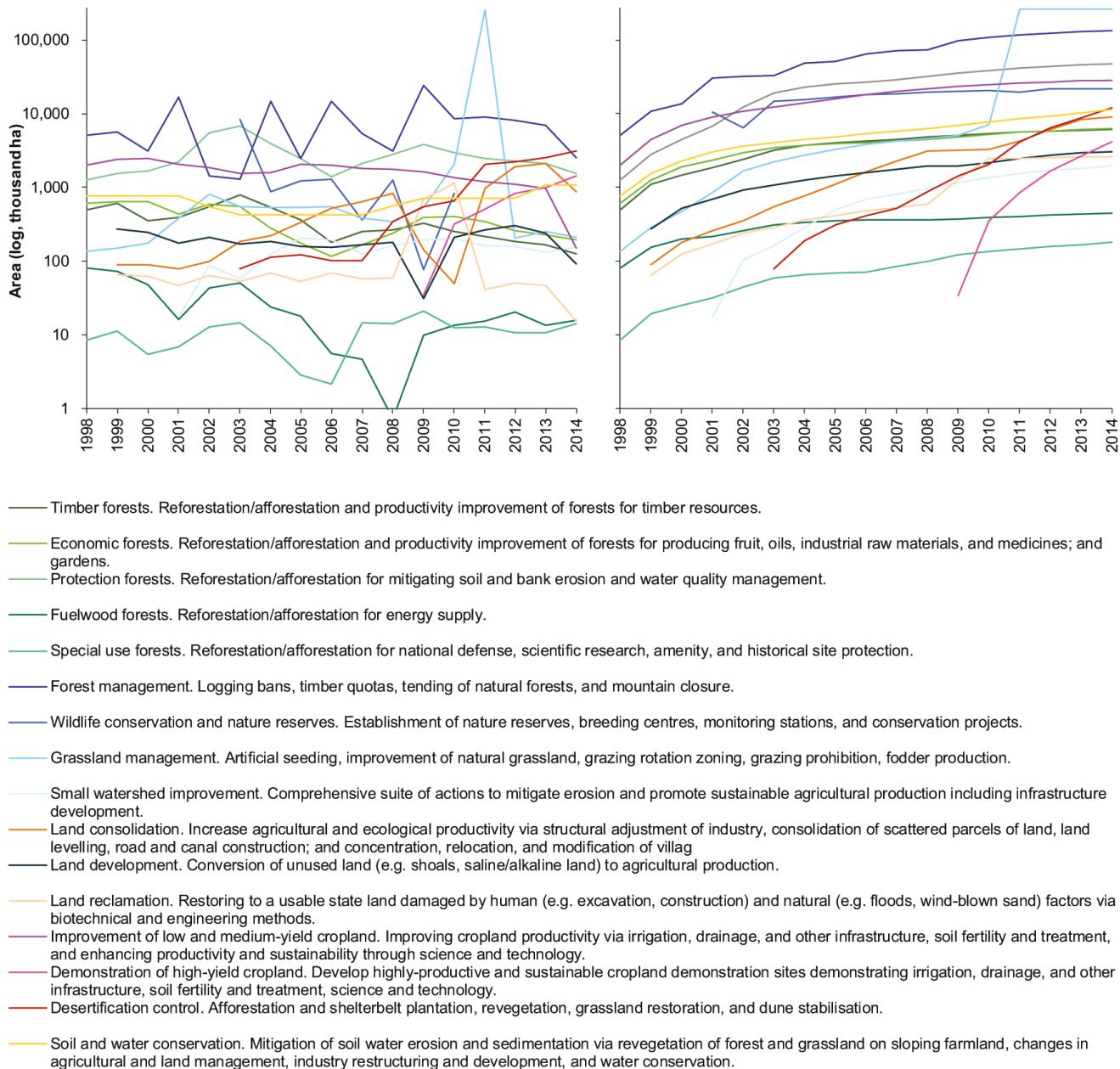
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Supplementary Fig. 1. Annual (left) and cumulative (right) area of on-ground actions over time implemented under the 16 major sustainability programs from 1998–2014. No area data was available prior to 1998, nor for 2015. Source data is presented in Supplementary Data 3.