The Economics of Ecosystems and Biodiversity (TEEB): promoting a sustainable agriculture and food sector

# Lessons learned from previous interventions for improving biodiversity outcomes in China's agri-food sector (Draft)

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# Summary

This report summarizes some of the key interventions targeting ecosystem and biodiversity conservation in the agri-food sector in China based on published literatures, and briefly describe the rationale, institutions, activities, results, and experiences learned from these interventions. The report is divided into three sections based on different agricultural sectors, namely cultivated crops, fisheries, and animal husbandry. We then briefly discussed the potential gaps in the current interventions for the application of the TEEB framework in a Chinese agricultural context. In doing so, we aim to provide a pool of interventions with the potentials for future scenario analysis.

Chinese domestic crop cultivation has received most of the focus in terms of agricultural ecosystem conservation due to the increasing population demand and the need for a greener production. Interventions in this category exceeds the other two both in terms of number and scale.

1. Land use and land cover changes and reforms

1.1 Natural reserves

- Institutional principles founded in 1994, amended in 2011 and 2017; emphasized the protection of representative geographical regions, natural ecosystems, endangered species, etc.;
- A total of 2750 natural reserves domestically in 2018, 463 at the national level;
- Sponsored by the central government, implemented by the ministries and regional authorities; research institution also involved;
- Ecosystem benefits significant, positive and negative social impacts both present;

1.2 Grain-for-green project

- Initiated in 1999, targeting deforestation, over-cultivation of slopes, soil erosion, ecological degradation, and poverty;
- Sponsored by the central government, jointly supported by local authorities and research institutions;
- Demonstrated effective cooperation between research institutions and governmental bodies at regional and local scales;

1.3 Water source protection areas

- Initiated in 2007, aimed at preserving water source;
- Sponsored and enforced by the government;
- Using fiscal measures to balance ecosystem services and economic development;

1.3 Designated agricultural areas

- Initiated in 2017, aimed at balancing economic development and food security, and increasing agricultural production efficiency;
- Sponsored by the central government, facilitated by the Ministry of Agriculture and Rural Affairs;
- Planed and zoned production of eight food and cash crops;
- Functional production zones and vital production zones set up;

2. Agricultural changes and reforms

2.1 Land tenure reform

- Based on the previous path that started in 1978, with new legislations passed in 2014, aimed to optimize land resources allocation and production efficiency;
- Sponsored by the central government, implemented by relevant ministries and local authorities; can be seen as an integral part of other agricultural initiatives;
- Rural cooperatives and rural land transfer are the two main forms of representation;
- Allowed private sectors to take part in the land re-allocation; potentially impacting all aspects of the agricultural value chain;
- Evidence on ecological impact scarce;

2.2 Agricultural supply-side structural reform

- Reform began in 2015, to achieve greener and more efficient production compatible with sustainability standards and competitive in the international market;
- Sponsored by the central government, facilitated by ministries and regional governments;
- Designated the nation's main agricultural development agenda in 2016;
- Compelling results manifested in the crop market, but ecosystem benefits hard to determine;

2.3 Controlling agricultural non-point source pollution

- Similar actions already in place, importance raised in 2015 by the No.1 Central Document, aimed at controlling the increasing pollution from agricultural production;
- Initiated by the central government, facilitated by the Ministry of Agriculture and Rural Affairs and the Ministry of Ecology and Environment;
- Positive environmental results already present, ecological results remain to be seen;

2.4 Digital agriculture

- Started in 2018, aimed at advancing rural livelihood, agricultural production, and urbanization processes;
- Sponsored by the central government, potential participation from state, regional, and local authorities, and public and private companies;
- Ecosystem effects yet to be determined, potentials promising;

3. Ecological initiatives and awareness raising

3.1 Conservation and Sustainable Utilization of Wild Relatives of Crops (CWRC)

- Started in 2007, dedicated to eliminating threats to the existence and diversity of wild relatives of cultivated crops;
- Sponsored by the GEF, facilitated by the Ministry of Agriculture and Rural Affairs and the UNDP;
- A participatory, incentive-based approach to involve local stakeholders through capacity building and continuous monitoring;
- Overall project objectives achieved, capacity building and stakeholder cooperation apparent;

3.2 Conservation of agricultural heritage systems

- Full project began in 2002; Chinese agenda materialized in 2016, and was emphasized again in the No.1 Central Document of 2018; aimed at safeguarding and sustainably managing the world's agri-cultural heritages;
- Funded by the GEF and implemented by the FAO; Chinese domestic implementation oversaw by the Ministry of Agriculture and Rural Affairs; active participation sought by local municipal governments, and supported by stakeholders from various levels;
- Specific interventions involved ecological compensation, organic agriculture, and ecological tourism;
- Fifteen heritage sites in China so far, successful conservation values and actions demonstrated at the project sites;

3.3 Promoting farmland biodiversity

- Started in 2007, aimed at conserving and utilizing farmland genetic diversity; in line with China's push to reduce chemical use and promote human and environmental health and agricultural ecosystem functions;
- Sponsored by the UNEP and supported by the GEF, facilitated and implemented by the Ministry of Agriculture and Rural Affairs; implementation oversaw by an international project management unit and international steering committee;
- Domestic policies, laws, and regulations implemented by the coalition and beyond;

- Project outcome mostly positive; methodologies developed and disseminated to local farmers;

3.4 Sustainable land and water management

- Started in 2012, aimed at combating the unsustainable use of land and water resources by agricultural practices, and to increase resilience to climate change;
- Funded by the FAO with GEF as partner, Chinese implementation at the provincial level as pilot;
- Post-project evaluation showed mostly successes; environmental effect promising, effect on biodiversity and ecosystem functions not yet quantified;

Chinese fishery policies have seen three main stages since 1978. Most of these fishery policies and regulations were developed and enforced by fishery authorities under the guidance of the central government and the Ministry of Agriculture and Rural Affairs.

1. Input and output management

1.1 The fishing licensing system

- Outlined in 1986, current version amended in 2013; aimed at controlling the access to fishery resources;
- Sponsored by the Ministry of Agriculture and Rural Affairs, enforced by regional and local fishery authorities;
- Actual ecological outcome debatable;

1.2 The fishery boat buyback and the vessel power control practices.

- Began in 2002, aimed at reducing the number of fishery boats operating at sea;
- Sponsored by the Ministry of Agriculture and Rural Affairs, implemented by regional and local fishery authorities;
- Number of vessels successfully decreased, but total tonnage increased, with increasing average fishing haul per annum;

1.3 Fishery personnel re-employment programme

- Started in 2003, aimed at reallocating fishery personnels to other sectors of the fishing industry;
- Sponsored by the Ministry of Agriculture and Rural Affairs, implemented by regional and local fishery authorities;
- Outcome not promising;

1.4 Closed fishery seasons practice

- Began in 1979, institutionally implemented in 1995; prohibits all fishing vessels from operating in designated seasons each year;
- Initiated by the central government, implemented and enforced by the Ministry of Agriculture and Rural Affairs and fishery authorities;
- Negative responses witnessed as a result;

1.5 Marine protective areas

- Officially initiated in 1995; aimed at protecting marine ecosystems and biodiversity;
- Initiated by the central government, implemented and enforced by the Ministry of Agriculture and Rural Affairs and fishery authorities;
- Few reserves with “non-fishing zone” status, conservation practices and ecological effects largely uncertain;

1.6 Total allowance catch system

- Legislation in place in 2000, aimed to cap the allowed total marine catch in a given time frame;
- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities;
- Effective monitoring lacking, regulation not yet implemented in the domestic waters;

1.7 The Zero and negative-growth targets

- Zero-growth target in place in 1999; negative-growth target in place in 2000; aimed to control marine total catch and to use marine resources sustainably;
- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities;
- Result promising, total marine steady between the years 2000 to 2009;

1.8 The double-control policy framework

- Initiated in 2017, aimed at controling the total number of fishing vessels and reducing the total marine catch;
- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities; in coordination with the central government agendas;
- Ecological effects not yet known;

2. Technical measures

- Early ones in place in 1990s, aimed at regulating marine catch using specific indices;

- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities;
- Comprehensive ecological effect data scarce;

3. Ecological initiatives and practices

3.1 Marine repopulation programme

- Began in mid-1980s, direct actions to boost marine wildlife resources and maintain sustainable population dynamics;
- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities; private participation by businesses as compensation;
- Over one hundred species repopulated up until 2008, no follow-up ecological assessment data available;

3.2 Habitat restoration

- Began in early 2000s; aimed at providing habitat to support marine communities;
- Initiated and implemented by the Ministry of Agriculture and Rural Affairs and fishery authorities; both public and private participation;
- Follow up ecological assessment data scarce;

4. Economic measures

- Early practices in place, systematic implementation in 2015; aimed at promote promoting fishery livelihoods and sustainable use of marine resources;
- Initiated by the Ministry of Agriculture, facilitated by the Ministry of Finance; jointly implemented by fishery authorities;
- Ecological effect debatable;

The Chinese government has instigated a number of policies and regulations promoting the sustainable development of livestock and poultry industry. Modern sustainable requirements were further incorporated into the animal husbandry development agendas in 2007. Some of the main interventions are listed as follows.

1. Conserving livestock and poultry genetic resources

- Initiated in 2005, aimed at conserving livestock and poultry genetic resources;
- Legislative sponsorship by the central government; implemented in the form of laws by the Ministry of Agriculture and Rural Affairs; implementation process in close link with international initiatives;
- Future agendas for improved conservation effectiveness outlined, but ecological impact at the state-level unknown;

2. Animal husbandry pollution standards

- First implemented in 2001, updated in 2003; aimed to regulate and control pollutant discharges along the production chain;
- Initiated by the Ministry of Agriculture and Rural Affairs, facilitated by the Ministry of Ecology and Environment with technical support;
- Empirical evidence on the ecological effects lacking, gaps exist between the initiative legislation and actual production;

Gaps could still be identified between the current domestic interventions and the possibilities as outlined by the TEEB framework. Top-down approaches excel in enforcement, reach, and continuance; but lack in mobilization and adaptability:

- TEEB can utilize new market devices reaching a range of potential stakeholders across disciplines, potentially tapping into stakeholder resources new to the arena;
- Market-driven actions more adaptable to spatial and temporal variations;

Potentials for TEEB application

The economics of ecosystem and biodiversity (TEEB) aims to monetize the economic benefits of biodiversity and ecosystem services, and to incorporate market forces in facilitating the decision-making process and the link between science, policy, and economic instruments.

While the Chinese government has recognized the intrinsic and external values of biodiversity and ecosystem services, and has incorporated the ideology that “lucid waters and lush mountains are invaluable assets” into the core principles of the nation’s green development agendas, we could still identify gaps between the current interventions and the possibilities as outlined by the TEEB framework. The most important one being the level of resources mobilized. Most of the interventions listed in this report were top-down approaches initiated by the central government or inter-governmental organizations, facilitated by relevant ministries, and implemented by subordinate agencies or local authorities (Table 1). As such, while they excel in enforcement, reach, and continuance, they often lack in mobilization and adaptability. As TEEB attempts to present a quantifiably valued ecosystem to the general audience, it could utilize new market devices reaching a range of potential stakeholders across disciplines (Ring, et al., 2010). An active participation from the bottom up could potentially tap into stakeholder resources new to the arena, and bring together players from all aspects of the discipline by bridging their differences of understanding. At the same time, market-driven actions are far more adaptable to spatial and temporal

variations than top-down approaches, meaning that regional conservation practices could tailor to their own developmental agendas.

Potential applications could be useful in multiple cases as stated in the report. In summary, most interventions could benefit from the TEEB framework because of its two unique characteristics. The first is the framework's outreach potential. Interventions such as the protected area initiative and Grain-for-green project were often unable to quantify non-use ecosystem benefits to the general audience, especially to residents in and around the project areas whose lives have drastically changed due to the processes. The TEEB framework offers us a tool to monetize conservation practices to this particular group of people who would otherwise not be able to fully grasp the importance because they were either ill-informed or unfamiliar with the subject. If outreach were to be conducted following the TEEB framework, the projects could potentially attract participants and financiers interested in, or would otherwise benefit from, the environmental improvements. This would ease the financial burden on the government and mobilize social forces to participate in the ecological restoration process.

The second is the framework's economic perspective towards ecosystems. Interventions that involved eco-compensations were often criticized because they applied certain universal compensation standards across different regions. Therefore, compensation was unable to reflect regional differences and were thus likely to generate uneven conditions that favoured some regions while neglecting others. Similarly, we could often find miss-matches between the central government's goals and regional governments' efforts in ecological interventions as national-level projects sometimes puts insufficient consideration on local interests in the process. The TEEB framework offers unique monetary perspectives in evaluating and quantifying the ecological processes and the economic benefits, from which quantifiable assessments would be made that could inform the higher-level policy makers of the specific compensations or actions necessary. Successful implementation of the framework could support the development of regional-specific compensation standards, and considerably add to the local adaptive capacity, and in turn promote effective local participation.

Strict protection is far from suitable in today's economic setting, an effective conservation strategy is one combing the conservation and sustainable use. The TEEB framework can link these two categorically different aspects that were once difficult to quantify and thus hard to balance. Since any successful conservation requires lengthy and continuous actions, maintaining balance between conservation and economic development is key in ensuring future success.

| Intervention | Time of significant implementation | Summary | Examples of key impacts |
|---|---|---|---|
| Ecological Compensation | 2004 (national level) | Cash compensation for ecological services | Social capital: balancing ecological and economic development |
| Natural reserves | 1994 (amendments in 2011 and 2017) | In-situ protection of ecosystems, areas, species, etc. | Natural capital: restricted access to natural resources |
| Grain-for-green project | 1999 | Revegetation of sloped croplands and barren lands | Natural capital: habitat restoration |
| Water source protection areas | 2007 | In-situ protection of water resources with limited use | Natural capital: sustainable use of resources |
| Conservation and Sustainable Utilization of Wild Relatives of Crops | 2007 | In-situ and ex-situ conservation of genetic resources | Natural capital: preservation of wildlife genetic resources |
| Promoting farmland biodiversity | 2007 | Utilizing farmland diversity for ecological services | Natural capital: increased farmland diversity |
| Sustainable land and water management | 2012 | Applying sustainable land-water management in farmlands | Natural capital: sustainable use of resources |
| Land tenure reform | 2014 | Reforms in land tenure and cultivation rights | Social capital: allowing large-scale agricultural production |

| | | | |
|---|---|---|---|
| Agricultural supply-side structural reform | 2015 | Promote supply-demand balance by raising production efficiency and quality | Natural capital: reorganizing ways of production through strategic planning |
| Controlling agricultural non-point source pollution | 2015 | Reduce chemical input and output in agriculture | Production capital: limiting chemical production and use in the agri-sector |
| Conservation of agricultural heritage systems | 2016 | In-situ conservation of unique agricultural systems | Natural capital: protecting sustainable-use model systems |
| Designated agricultural areas | 2017 | Main food security by optimizing regional-specific agricultural | Natural capital: re-designing regional agricultural focuses |
| Digital agriculture | 2018 | Increasing digital access to facilitate rural development | Production capital: increasing digital infrastructures and access in rural regions |
| Closed fishery seasons practice | 1979 (major reform in 995) | Seasonal fishing | Natural capital: allowing marine resources to recuperate |
| Marine repopulation programme | 1984 | Rewilding marine populations | Natural capital: rewilding |
| The fishing licensing system | 1986 | Licensed and regulated fishing | Production capital: restricting access to marine resources |
| Technical measures | 1990s | Technical regulations on fishery practices | Production capital: controlling fishing methods |
| Marine protective areas | 1994 | In-situ conservation of marine resources | Natural capital: in-situ conservation |
| The Zero and negative-growth targets | 1999 | Limiting the growth of marine total catch | Production capital: limiting fishing vessels and total production |

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|---|---|---|---|
| Total allowance catch system | 2000 | Limiting the growth of marine total catch | Production capital: limiting fishing vessels and total production |
| Habitat restoration | Early 2000s | Reconstructing marine habitats | Natural capital: habitat restoration |
| The fishery boat buyback and the vessel power control practices | 2002 | Reducing fishery vessels | Production capital: reducing fishing vessels and total personnel |
| Fishery personnel re-employment programme | 2003 | Reducing fishery personnel | Production capital: reducing fishery personnel directly related to the catch process |
| Economic measures | 2015 | Compensation for fishery personnel | Human capital: alternative livelihoods and subsidies |
| The double-control policy framework | 2017 | Limiting the growth of marine total catch and vessels | Production capital: limiting fishing vessels and total production |
| Animal husbandry pollution standards | 2001 | Regulating animal husbandry chemical input and output | Production capital: regulating the type and amount of chemicals in the livestock sector |
| Conserving livestock and poultry genetic resources | 2005 | In-situ and ex-situ conservation of livestock genetic resources | Natural capital: preserving livestock genetic resources |

Table 1 Brief summary of the interventions in the Chinese agri-food sector. Interventions ordered by year of appearance.

# General introduction

China has been supporting over 20% of the world's population with approximately 10% of the total arable land. While the historically rich diversity in the agricultural landscape had been successfully preserved with the traditional household-level farming system, it is being challenged by the increasing need for a more modern and intensive agriculture characterized by scaled production methods. The reforms starting in the late 1970s have resulted in drastic changes in the agricultural landscape, and evidence show that such changes have been followed by a rapid loss of biodiversity and ecosystem services (Liu et al., 2013). Biodiversity and ecosystem functions in agricultural ecosystems has gained attention in literature and in the policy realm because they contribute significantly to agricultural productivity, and to the overall global biodiversity (Norris, 2008; Tilman, 1999). While farming practices that favour biodiversity and ecosystem services within the agricultural ecosystem have been adapted and assessed in developed regions such as the European Union the United States, it has not received enough attention in China. As the nation undergoes urbanization and agricultural land reforms, it is important to systematically assess the existing policies and interventions dealing with biodiversity and ecosystem conservation in the agricultural ecosystem.

The Economics of Ecosystem Biodiversity: Promoting a Sustainable Agriculture and Food Sector (TEEB Agriculture and Food Implementation), hosted by UN Environment and supported by the EU, has developed a framework that comprehensively assesses the impacts of all practices within the agri-food value chain. The current project is an extension of the initiative. It aims to assess interventions that has been, or will be, implemented in China that focused on, or will focus on, stimulating positive livelihood and biodiversity benefits, with special reference to the outcomes on natural, human, social, and production capitals.

This report serves as one of the background documents to the current inception workshop, which will focus on identifying the policies and interventions to be studied though the life of the project. The report contains China-specific analysis of the types of interventions that have been (or will be) applied to improve biodiversity and ecosystem outcomes in the agri-food sector across the agricultural value chain. Interventions have been selected only when they could potentially affect ecosystems and biodiversity. Information gathered were based on published literatures, both international and domestic, and publicly accessed government documents; and briefly describe the rationale, institutions involved, specific activities, results, and experiences learned. Some of the interventions listed here were part of, or inherently rooted in, the "National Sustainable Development Plan for Agriculture (2015-2030)" (Ministry of

Agriculture et al., 2015; later became the Ministry of Agriculture and Rural Affairs), which listed five main missions in agricultural development, namely optimized zoning of production, conservation of cultivated land, increased water efficiency, controlled pollution, and restoration of agricultural ecosystem functions. These interventions are divided into three main categories, namely cultivation, fishery, and animal husbandry, their timeframe was also summarized to show the gradual changes of conservation values in the agri-food sector (Table 1). This report aims to provide a pool of interventions with the potentials to be used for future scenario analysis.

## Special case: ecological compensation

We present ecological compensation here as a special case not only because it facilitates ecological interventions without directly targeting conservation in itself, but also because it is the foundation on which many ecological interventions were built on.

The earliest eco-compensation attempts dated back to the early 1990s, when the State Council outlined compensation practices for the use of forest resources. But these practices mostly reflected the needs of specific regions instead of the entire country. In 2004, the first official eco-compensation fund was established for forest resources, accompanied by the "Management Guidelines for the Subsidy Funds of the Central Treasury for Forest Ecological Compensation" (Ministry of Finance & Department of Forestry, 2004). Also, in 2005, the Eleventh Five-year Plan outlined the general principles stating that national-level eco-compensation schemes should be developed in response to the urgent ecological restoration needs, especially the gap that existed in relevant policies that caused uneven distributions of ecological and economic benefits between the protectors and beneficiaries, or between the offenders and victims. When the Twelfth Five-year Plan was issued in 2011, it outlined the requirements and recommendations for eco-compensation, detailing some of the key aspects that would pave way for the future framework.

Even though the national level regulation for eco-compensation has not yet been implemented, regional and sub-regional practices have flourished. This was made possible by the "National Functional Zoning Plan" which established spatial and institutional foundations for the compensation schemes (National Development and Reform Commission, 2010). The first eco-compensation schemes were piloted in the forestry sector, offering RMB 225/ha/year to approximately 125 million hectares of forest nationwide. The second round was applied to grasslands beginning 2011, offering RMB 90/ha/year to non-pastoral grasslands and RMB 22.5/ha/year to balanced-pastoral grasslands. The third group of schemes targeted water resources. This

group mostly featured horizontal (region-to-region) eco-compensations along river catchments. One notable case was the eco-compensation scheme in the Xin'an river basin starting in 2004, which involved three cities in two provinces (Anhui and Zhejiang). It was the first project to include horizontal water eco-compensation across provincial borders. As a result of the eco-compensation and the relevant interventions it had facilitated, environmental indices in the area significantly improved. The fourth group built on pre-existing schemes that dated back to 2003, focusing on providing eco-compensation to mining regions. The last group focused on transfer-payment directed towards ecological function zones. Meanwhile, relevant authorities led by the National Development and Reform Commission and the Ministry of Finance have been gathering experiences and empirical support, and working with research institutions and international organizations to form the national level regulations for eco-compensation schemes.

Even though we cannot dedicate any specific changes in ecosystem to the ecological compensation scheme per se, it is the absolute must in any successful interventions. The schemes have contributed to economic development in the less-developed western regions of China, strengthening their unique positions in the nationwide ecological agendas.

However, because eco-compensation schemes are still under development, issues have arisen that require our attention in the coming stages. We have selected two issues here that could potential benefit from TEEB applications based on review of pertinent literature.

The first issue surrounds the compensation standards. Regional practitioners have reported cases where compensation based on current standards are unable to cover farmer losses in the eco-restoration processes. The compensation standards are also said to be too general in certain areas, not reflecting regional differences. Furthermore, current compensation funds mostly relied on state financing, which put heavy burden on the Central Government's budget. The second issue concerns the eco-compensation framework currently at play, most notably the lack of horizontal eco-compensation schemes due to gaps in regulations and legal frameworks, and most importantly, the absence of an effective mechanism and platform on which exchange and agreements can be made between receiving and implementation regions of interventions or between upper and lower catchments. The TEEB framework offers quantitative assessments of ecosystem services and disseminates them through a network of public and private stakeholders in an economic language most can easily understand. If implemented, TEEB could offer solutions to the abovementioned issues and promote effective eco-compensation schemes.

# Interventions in the cultivation of crops

Domestic crop cultivation has been affected by many policies and regulations both in direct and indirect ways. Such intervention might not have been implemented to purposely target biodiversity and ecosystem functions, but has nonetheless caused changes in these aspects. The interventions summarized here include land use and land cover changes and reforms, agricultural means-of-production changes and reforms, and ecological initiatives and awareness raising.

# 1. Land use and land cover changes and reforms

Land use and land cover changes and reforms include national level policies to set up areas or regions dedicated for specific purposes, such as the conservation of biodiversity, restoration of natural ecosystem processes, and preservation of natural scenery and/or unique geological features. Not all interventions summarized here were intended for agri-sector impact, but they directly or indirectly resulted in changes in the agricultural value chain.

### 1.1 Natural reserves

The existing principle for establishing and monitoring natural reserves was founded in 1994, and mended twice in 2011 and 2017. Its guidelines emphasized the protection of representative geographical regions, natural ecosystems, endangered species, etc. As of 2018, there were a total of 2750 natural reserves in China, 463 of which were at the national level (MEE, 2019). The initiative was sponsored by the central government, and implemented by the ministries and regional authorities. Research institution were also involved in the site selection, assessment, and monitoring of the process. Natural reserves had a large impact on natural capitals, and extended impact on human and social capitals in the agricultural value chain.

Though most reserves were based in remote areas less affect by human activity, the founding of any site was still often accompanied by a transition of local land use types and intensity. Agricultural and residential land were slowly replaced by natural and semi-natural ecosystems, and residents, if any, were often migrated to other areas. Benefits to natural ecosystem was significant, approximately 66.7% of the national-level natural reserves achieved their goal in protecting forest coverage, reducing deforestation rate to under 1.1% per annum in programme-covered areas (Ren et al., 2015). The resulting benefit to biodiversity and ecosystem services was also well documented (Xu et al., 2017). The natural reserve initiative has generated both positive

and negative impacts with regard to human and social capitals. The most prominent of the positive impacts arises from the development of eco-tourism in natural reserves, in which rural stakeholders were often involved in the development, management, and maintenance of infrastructures and services. This can significantly boost local economy, creating markets and jobs conveniently accessed by the indigenous people. At the same time, the increased revenue draws labour from crop production, which could in-turn benefit local vegetation and biodiversity. Local stakeholder participation is often strengthened by continuous ecological awareness trainings and capacity building demonstrations organized by the government, research institutions, and other private players, which add to the local knowledge regarding conservation and sustainable livelihoods. However, like most natural reserves in the world, Chinese reserves usually involve certain levels of strict protection, mostly enforced in the core area. This has sometimes generated situations in which people were forced to move from their original place, or "conservation refugees". Some researchers argue that natural reserves, in the strict sense, can create environmental backlash and setbacks to sustainability efforts (Geisler, 2010). In cases where economic revenue is shared between the leading conservation agency and local stakeholders, disproportional benefit distribution among stakeholders can result in a break of trust and reduced support by the locals, such as the case in Wolong Nature Reserve for Giant Pandas (He, et al., 2008). The continuous and sustainable development of eco-tourism in these regions calls for enhanced local participation (He, et al., 2008).

### 1.2 Grain-for-green project

The Chinese Grain-for-Green project was initiated in 1999 to combat deforestation, over-cultivation of slopes, soil erosion, ecological degradation, and poverty by reconverting cropland back to forest or grassland, and afforesting barren land. This was a national level project sponsored by the central government, and jointly supported by local authorities and research institutions.

While the project was intended for natural capital outcomes, intervention was mostly in the form of incentives that originated from the central government, and was given to farmers through the hands of local authorities. As such social capital was the most directly affected aspect. Institutional arrangements were in place that encouraged local stakeholders to participate in the cropland and barren land revegetation processes, including regulations, capacity building programmes, and trainings and demonstrations. Human capital was also moderately affected, as a proportion of local residents sought other work opportunities afterwards.

was mostly limited to the production aspect of the agricultural value chain, inciting changes in natural, human, and social capitals. Specific actions include eco-restoration and adjustment of land use, redesigning infrastructure, and improvement of resource use efficiency. These were achieved with the help from research institutions by providing demonstrations and livelihood capacity building.

The Grain-for-green project was the largest ecological initiative in terms of geographical area covered, stakeholders reached, and government resources invested. The entire project can be divided into two stages. The first stage began in 1999. According to the "Cash Compensation Management Guidelines for the Grain-for-green Project" (Ministry of Finance, 2002), the national-level guidelines put cash compensation at approximately 160 RMB/mu (crops valued at 1.4 RMB/kg at 100kg) for the Yellow River and Haihe River catchment, and 230 RMB/mu for the Yangtze River catchment. Duration for compensation was two years for grassland, five years for economic forest, and eight years for ecological forest. Additionally, there was a 50 RMB/mu seed compensation. The guideline also stated that regional guidelines were to be built on top of the national guidelines with compensation standards equal to or exceeding the national standards.

The project was initially piloted in three western provinces Shaanxi, Gansu, and Sichuan, and quickly spread to cover 174 counties in thirteen provinces in western China. By the end of 2001, the project has successfully seen over one million hectares of cropland converted, with an additional one million hectares barren land afforested. By the end of 2008, the first stage of the project expanded to cover over twenty-five provinces all over the country, implementing in over twenty thousand counties/towns, with over sixty million households involved.

While the first stage of the project was successful in reaching its intended goals, it also showed few shortfalls in the design and implementation stage, most prominent of which was the universal compensation standard within catchments. This approach was instigated to reduce risks of disagreement between regional and the central government. As a result, compensation standard was not adjusted to reflect regional differences, and the financial cost for compensation was considerably higher than anticipated. Another important issue during the project implementation was the miss-match between the central government's goals and regional governments' efforts. Because universal compensation standard was high and that compensation was given though the regional government, regional authorities were keen on advancing the size of implementation in their own jurisdiction. This resulted in regional revegetation progressing faster than, and not according to, the central plans. These issues facilitated changes in the crop market, manifesting in reductions of the domestic food stock and increases of crop price,

which ultimately led to adjustments to the Grain-for-green policies in 2003 that carried on until 2014.

Starting in 2014, the second stage of the project was initiated in response to the Green Development and Ecological Civilization goals. The "General Guidelines for the New Round of Grain-for-green Project" was drafted and handed down to regional governments for implementation (National Development and Reform Commission et al., 2014). The second stage of the project was built on the experiences of the first stage, with updates in the implementation goals and compensation standards to reflect national development. The general goal of the second stage was to revegetate over 2.8 million hectares of sloped croplands and/or deteriorated croplands. The updated standard put cash compensation at 1500 RMB/mu for forests, and 800 RMB/mu for grasslands. In 2015, the "Notice on Expanding the New Round of Grain-for-green Project" was issued. The new guidelines put compensation standard for grasslands at 1000 RMB/mu.

By 2019, the second phase of the project has designated close to four million hectares of cropland revegetation, which consists of 3.66 million hectares of forest and 0.33 million hectares of grassland. One notable difference of the second phase was lifting the quotas for economic forest revegetation. This led to fast coverage of economic forests in the project regions, which facilitated the development of agri-forest products and ecotourism. In total, the two project phases have seen over 33.3 million hectares of cropland revegetation, costing over RMB 500 billion in government funds.

The Grain-for-Green project demonstrated the effectiveness of cooperation between research institutions and governmental bodies at regional and local scales, and was an exemplary case of research-demonstration-transfer. In the case of Yangou watershed, located in the northern part of the Loess Plateau, China, interventions resulted in an increase of per capita annual income from 763 RMB in 1997 to 1,855 RMB in 2005 (130%), all the while shifting income revenue from traditional agriculture towards economic cultivation and non-agricultural wages, reducing pressure on the regional ecosystem. Sociological capacity building empowered local communities by demonstration and training programs, which guaranteed local evolvement in the restoration processes.

### 1.3 Water source protection areas

The preservation of water source represents one of China's key efforts to sustainably management the use of non-renewable resources. Current policy framework has outlined three types of water source protection areas, from tier one areas where all forms

of agricultural production are ceased and all lands acquired by the state, to tier two areas where controlled production are permitted but strictly monitored for environmental risks, and finally to tier three areas where continuous monitoring mechanisms are in place. These interventions were government sponsored and enforced, and focused on the sustainable use of natural capitals by subsidizing human and social capitals, which impacted the upper sector of agricultural value chain, including raw material gathering, production of agri-materials including machinery and chemical substances, and cultivation. The establishment of these regions usually involves ecological compensation or payment for ecosystem services (PES) designed to support local livelihood while enforcing certain levels of environmental standard that could potentially jeopardize economic revenue. Studies have found that these activities were crucial in promoting ecological protection and sustainable development (Ouyang et al., 2013). However, the scopes of these actions were usually limited and lacked systematic institutional design. Current Chinese research on ecological compensation and PES focused on compensating for positive actions, frequently neglecting compensation for reduction of negative impacts, which was often the case in water source protection areas.

### 1.3 Designated agricultural areas

In 2017, the central government issued guidelines for establishing functional crop production zones and vital agricultural product production zones. These guidelines were intended for the following two aspects of Chinese agro-production: 1, the ever-growing conflict between industrialization and urbanization and the need to maintain food security; 2, the need to optimize agricultural production tailored to regional features in order to increase efficiency. This initiative was specifically intended for the production aspect of the agricultural value chain, targeting human and social capitals in the process.

This was a nation-level initiative designed and sponsored by the central government, and facilitated mainly by the Ministry of Agriculture and Rural Affairs. Food crops such as paddy rice (*Oryza sativa*), winter wheat (*Triticum aestivum L.*), and maize (*Zea mays*), and economic crops including soy (*Glycine max*), cotton (*Gossypium hirsutum*), rapeseed (*Brassica napus*), sugar cane (*Saccharum officinarum*), and natural rubber (*Hevea brasiliensis*) were included in the current guidelines. The intended goal was to designate approximately 60,000,000 ha as functional production zones, and approximately 15,866,668 ha as vital production zones (5,333,334 ha shared between the two). All zones will be based on preexisting agricultural production regions, which means that no new land will be transformed. However, intensity in the designated zones will be significantly increased, which will most likely be achieved through increased

input in manual labour, machinery, and resources. Human and social capitals will likely benefit from the process, but biodiversity and ecosystem services will likely be affected by the raising intensity of agricultural production.

# 2. Changes and reforms in the means of production

Agricultural changes and reforms include interventions targeting the production, distribution, and consumption aspects of the agricultural, pastoral, and fisheries value chain. Initiatives in this category were generally intended to incite changes by controlling or limiting the capitals being inputted and extracted out of the agricultural systems directly.

### 2.1 Land tenure reform

Land tenure reform, in the non-strict sense, can be interpreted as changes in the distribution and/or ownership of land resources. It includes the establishment of agricultural cooperatives and rural land transfer. With urbanization, industrialization, and the development of modern agricultural technology, the conditions of Chinese rural labour and means of production has seen significant changes over the years. Meanwhile, the scarcity of arable land and the household-level production method have resulted in an average farmland size of only 0.96 acres per household (China Agricultural Development Report, 2016). The mismatch between increased agricultural efficiency and the traditional land tenure called for the development of scaled production. Rural cooperatives were the first step toward this goal. In 2014, The General Office of the CPC Central Committee and the General Office of the State Council issued guidelines permitting rural land transfer, which was an institutional reform to further support the development of scaled production. This initiative intended to optimize land resources allocation and production efficiency by affecting the production aspect of the value chain, making changes in the social capital to incite redistribution of human and produced capitals. It was also in line with other agricultural initiatives and projects such as the designation of specific agricultural zones, the supply-side reform, and the control of agricultural non-point source pollutions.

Rural cooperatives, as a new form of rural organization, have been established both by farmers themselves and through government interventions. Though generally considered a market-based activity, cooperative does provide farmers with access to government funds and opportunities supporting agricultural innovation. The development of rural land transfer has been a much more complex case. Though certain levels of land-right transfer have already been practiced for years, it was always a

legally sensitive issue. Starting from 2016, farmers were officially allowed to transfer land rights to individuals or companies, with institutionally guaranteed separation of farmland ownership rights, contract rights, and operating rights. This new reform would replace the household responsibility system (HRS) that has been in place since 1978. Other than government authorities and research institutions, private companies such as banks and digital service providers were also involved in the surveying, mapping, and marketing of the reform process, creating a huge market that could potentially generate considerable fiscal flow in rural areas. This reform will have considerable impact on all aspects of agricultural capitals, and would most likely change the existing manufacturing, cultivation, and distribution structures.

Chinese rural cooperatives predominantly facilitate economic cooperation and market integration, which was supported by agricultural policies and the Cooperative Law of 2007 oriented towards the commoditization of smallholder farming (Song et al., 2013). As some researchers suggested, there are some cooperatives not driven by economic incentives, but by the fulfilment of agro-ecological and socio-cultural functions (Song et a., 2013). However, while the benefits and challenges of cooperatives to household livelihood and rural development have been studied, the ecosystem response has largely been ignored. Evidence from economic data suggest improved revenues, living standards, and education in regions with successfully implemented cooperatives, which may lead to improved environmental awareness.

Rural land transfer has been found to benefit rural development and urbanization, but evidence on the ecological impact of rural land transfer is scarce. However, sustainable modern agriculture is said to be beneficial toward ecology and the environment, which will be facilitated by more efficient and better managed scaled production. On the national level, redistribution of arable land would likely free certain areas from cultivation, the ecological effects of such changes remain to be seen.

### 2.2 Agricultural supply-side structural reform

The idea for agricultural supply-side structural reform was first brought up in late 2015 in the Chinese Communist Party (CCP) Central Committee's Agricultural Work Conference. The main rational behind this initiative was the increasing demand, by the consumers and the environment, for greener and more efficient production compatible with sustainability standards and competitive in the international market. It was also partially connected to the continuous food security requirements, which has evolved from a demand on cultivated area and yield to the demand for better overall balance. It was designated the nation’s main agricultural development agenda by 2016’s No.1 Central Document. The initiative intended to incite structural reform to the supply side

of agriculture production, more specifically, to achieve optimal supply-demand balance by raising the efficiency and quality of agricultural supply to meet consumer demands. The reform initiative was mainly facilitated by the Ministry of Agriculture and Rural Affairs, while regional implementation was handled by the respective agricultural bureaus.

Now three years into the reform, the nation has already seen changes manifested in the crop market. A good example of which is the yield and price of maize in the recent years. Since 2012, domestic policy supported the cultivation of maize, which resulted in a total cultivated area of 38,120,000 ha in 2015, highest in the world. Meanwhile global maize price has significantly dropped over the years, adding serious burden to the nation's economy. The supply-side reform has reduced maize cultivation by 2,000,000 ha in 2016, and approximately 666,667 ha in 2017. Though lacking empirical data detailing the ecosystem benefits of such change, it is safe to assume that an optimized production efficiency led to increased efficiency in resource use, and reductions in the raw material production side of the agricultural value chain.

### 2.3 Controlling agricultural non-point source pollution

Agricultural and rural non-point source pollution refers to pollutants disseminated into the soil and water body through drainage or leaching effects in non-specific areas. The main pollutants include residues from excess use of nitrogen, phosphate, and fertilizers. The 2010 First National Pollutant Source Census showed that agricultural non-point source pollution had become the main cause of water pollution in China, contributing to 43.7%, 57.2%, and 67.4% of the total chemical oxidative demand (COD), total nitrogen, and total phosphorous load, respectively. In light of this increasing pollution from agricultural production and as part of the general pursuit of Ecological Civilization, the central government has included the control of agricultural non-point source pollution in the No.1 Central Document in 2015. The goal of the initiative was to systematically control the use of agricultural input such as water, fertilizer, pesticide, animal manure, crop straw, and plastic mulch by the year 2020.

The initiative adopted that of a top-down approach, guided by the central government and led by the Ministry of Agriculture and Rural Affairs and the Ministry of Ecology and Environment, and supported by other ministries and regional authorities. Research institutions, at both national and local levels, jointed the initiative by providing scientific guidance, assessment, and continuous monitoring of the intervention activities. According to policies such as the "National Sustainable Development Plan for Agriculture (2015-2030)" (Ministry of Agriculture et al., 2015), the "Action Plan for Controlling Agricultural and Rural Pollution" (Ministry of Agriculture and Rural

Affairs & Ministry of Ecology and Environment, 2018), and the "Opinions on Implementing the Control of Agricultural Non-source pollution by the Ministry of Agriculture" (Ministry of Agriculture, 2015), the initiative mostly focused on the following aspects:

The first was promoting water-efficient agriculture, and increasing overall agricultural water efficiency. This was in coordination with river-catchment ecological restoration efforts. The general goal was to maintain agricultural water use to below 3720 cubic metres by the year 2020, and increase agricultural irrigation efficiency coefficient to 0.55. This effort mainly targeted production capitals, reflected by the construction of more efficient irrigation facilities and aqueducts in rural areas.

The second aspect was controlling the use of fertilizers and pesticides, and allowing zero-increase of these two substances. This general goal was to increase fertilizer-use efficiency to above 50%, pesticide-use efficiency to over 40% by the year 2020. These efforts mostly targeted the human and social capitals, focusing on building farmers' capacity in applying scientific guidance in the application of these chemicals, and establishing more rigorous control measures for agricultural chemicals.

The third aspect was promoting pollution control in the livestock sector. This involved planning more strategic and environmental-friendly livestock raising techniques and standards, and constructing relevant recycling facilities. These efforts mainly targeted the production and social capitals.

The fourth aspect was controlling the use of agricultural mulches, which involved more stringent measures and standards on the production and use of plastic mulches in rural areas. It also pushed for demonstration of mulch-recycling methods based on plastic-recycling networks and industries. These efforts put heavy emphasis on the production capitals.

The fifth aspect focused on efficient utilization of straws in rural areas. According to the guidelines, resources will be allocated to the demonstration of straw harvest, stock, and treatment methods. Institutional arrangements will also be in place to facilitate marketable transactions of straw resources. The general goal was to achieve an 85% overall recyclability of straws by the year 2020. These actions leaned toward the production and social capitals.

Other than the national-level guidelines, the central government also issued action plans targeting regional-level pollutions, most noticeable of which being the "Guidelines for Accelerating the Control of Agricultural Non-point Source Pollution in the Yangtze River Economic Belt" (National Development and Reform Commission et al., 2018).

This policy outlined the necessity for accelerating pollution control in the Yangtze River Economic Belt, one of the main food oil, livestock, and fisheries production zones in China. It outlined region-specific goals for agricultural pollution control and sustainable use of resources.

As a result of the joint effort, domestic fertilizer efficiency for paddy rice, maize, and winter wheat has increased from 35.2% in 2015 to 38.8% in 2017; the goal of zero increase in total fertilizer input was also achieved in 2017, three years ahead of schedule; and domestic pesticide efficiency increased from 36.6% in 2017 to 38.8% in 2017, with total input amount deceasing for the third consecutive year.

Agricultural non-point source pollution has been in the government's radar for over three decades, while the joint effort demonstrated the nation's dedication to solving this issue, continuous and successful alleviation still requires the following actions be taken. Firstly, a deeper knowledge of the pollutant transfer between the soil-water interface and the underlying biogeochemical processes that influence the dissemination and translocation of pollutants, as well the efficacy of any countermeasures. Secondly, integrate ecosystem functions into the anti-pollution interventions, such as optimizing land use and landscape design to facilitate resource recycling and increase the efficiencies of nitrogen, phosphorous, etc. Of course, these must be developed based on extensive research and empirical evidence, which requires increased institutional participation and support. Finally, encourage and facilitate private sector involvement in the interventions. While a top-down approach can be extremely well-funded and can mobilize multi-level actions, it does not offer the same adaptability and reach. This could potentially be solved by including private companies and stakeholders in the process. The General Office of the CPC Central Committee and the General Office of the State Council issued guidelines permitting and supporting private involvement, the results of which remain to be seen.

The TEEB framework is uniquely positioned to facilitate some of these actions. By bridging the knowledge gap between policy makers, private sectors, and local farmers and stakeholders, we might be able to mobilize more effort and support in the pollution control process. One of the big challenges of controlling agricultural non-source pollution is reaching the farmers with updated perspectives and technologies. The lack of environmental awareness has made farmers part of the source of pollution, while they should in fact be regulators of the same problem. If an acceptable economic perspective can be offered to the farmers that wholesomely demonstrates the value of environmental protection, such issues might be alleviated.

### 2.4 Digital agriculture

As new technologies and products bloom in the era of information revolution, global and national economies have undergone drastic changes affecting livelihood and means of production. In 2018, the No. 1 Central Document first used the term “digital rural” in referring to the adaptation of information technology to advance rural livelihood, agricultural production, and urbanization processes. The intended goal is to develop “smart agriculture” that would build rural capacities and increase overall agricultural efficiency. Though not specifically intended for ecosystem benefits, this initiative would significantly change human, social, and produced capitals, and affect production, distribution, and marketing of the agricultural value chain. The guideline detailed changes that would require participation from state, regional, and local authorities, and public and private companies. Specifically, the interventions included added communications infrastructure in the rural, capacity building and demonstration given to the rural residents regarding the reformed means of production, digitalized rural landscape and agricultural planning for cultivation monitoring resource use control, increased interconnection between production and consumption by efficient transportation, and digital monitoring and guidance of fertilizer, pesticide, and water use by establishing the internet of things (IoT) in rural regions. As the initiative is still under its implementation stage, ecosystem effects are yet to be determined. However, the issuance of the guidelines in 2018 saw a boost of agricultural over-the-air (OTA) sales to RMB 300 billion within the same year. This growing market demonstrated the initiatives potential to significantly optimize transportation and distribution of agricultural production materials and produced goods, which can potentially improve the overall efficiency of the entire agricultural value chain.

## 3. Ecological initiatives

Conservation of biodiversity and ecosystem functions has always been one of the main focuses of China’s national development plan. Since as early as 1987, China has issued its guidelines regarding the protection of nature. And in 1991, during the negotiations of the Convention of Biological Diversity (CBD), the then Bureau of Environmental Protection of PRC, predecessor of the Ministry of Ecology and Environment of PRC, had already instigated conservation projects in coordination with the GEF, UNDP, and World Bank. Various projects and initiatives have since followed. However, these initiatives or projects were mostly broad in scope, not focusing on the agricultural ecosystem. This was partly because the nation’s focus has been set on maintaining

agricultural yield for an extend duration. The following summarizes some of the biodiversity and ecosystem interventions that focused on the agricultural value chain.

### 3.1 Conservation and Sustainable Utilization of Wild Relatives of Crops (CWRC)

This was a six-year project starting in 2007 dedicated to eliminating threats to the existence and diversity of wild relatives of cultivated crops, such as wild paddy, wild soy, and wild wheat varieties with close ties to the cultivated varieties, and harbouring genetic diversity pool that had potential significance to the crop genetic diversity in agricultural systems. Wild crop varieties are species that have survived in the wild without artificial manipulation. As contemporary high intensity crop production relies on cultivars selectively bred for local environments, the long-term domestication process had greatly reduced the genetic diversity of these varieties. An example of which is the cultivated winter wheat, evidence show that the loss of genetic variation has been estimated to about 69% (Haudry et al., 2007). This has exposed the cultivated varieties to biotic and abiotic stresses, especially in the context of climate change (Howden et al., 2007). By protecting wild varieties of the cultivated species, we are essentially protecting the genetic adaptability of crops.

The project was jointly funded by the GEF, the then Ministry of Agriculture, and the UNDP. executed by the UNDP, domestic implementation was supported and facilitated by the Ministry of Agriculture. The Project's adopted a participatory, incentive based approach to involve local stakeholders through capacity building and continuous monitoring of the conservation status at local and central levels in order to provide updated information to policy makers. The general implementation at the regional level involved agricultural bureaus at provincial to county levels, which was oversaw at the national level by a project office in the Ministry of Agriculture.

The overall project was deemed to have made good progress, and had achieved the intended objectives as set out by the funding agencies. It successfully demonstrated the effectiveness of combing wildlife conservation values within agricultural production. Though only implemented at few pilot study sites, the project successfully increased local capacities in areas where pilot studies were located, building cooperation between stakeholders and local authorities. An upscaled of this approach could proven to be an effective tool in agricultural biodiversity conservation. The project had also resulted in a monitoring system that could be used to support policy-making on conserving wild crop species at various levels.

Post-project evaluation revealed that project implementation was that of an adaptive process, in which adjustments were made based on prior experiences. It also identified

the need to strengthen policy framework among all levels of the government as the key barrier to successful implementation of the project. While the project team had leveraged additional funding for the project, it was gathered that jointly funded projects, especially those with both international and domestic sources, require better institutional arrangement for optimized performance. Also, while project objective was in line with GEF and national objectives, field level evaluation indicators should be kept up-to-date with relevant scientific literature and have practical significance.

### 3.2 Conservation of agricultural heritage systems

Diverse agricultural and pastoral activities worldwide have created many unique agricultural landscapes and production systems that were essentially the representations of local culture and indigenous wisdoms. The agricultural biodiversity supported by these anthropogenically managed systems were the combination of organisms, both wild and domesticated, that have evolved and adapted to the indigenous practice and their way of life. They not only provide beautiful landscapes and scenery on top the basic production functionality, but also sustain millions of small farming households by providing diverse livelihood opportunities. The globally important agricultural heritage systems (GIAHS) initiative was started by the FAO in 2002 to safeguard and sustainably manage the world's agri-cultural heritages by promoting public awareness, national and international recognition, and adjustments to national legislation and regulation. The initiative aimed to address the multi-faceted needs of the local stakeholders (sustainable farming, biodiversity conservation, etc.) in an integrated approach and balance agricultural conservation with rural development.

China, being a big and geographically diverse agricultural nation with thousands of years of agricultural history, has created many traditional agricultural systems that were unique and balanced in all aspects of the social and economic fields. The conservation and sustainable development of these systems have long been a focal point in China's contemporary agricultural development agenda, the idea to identify and protect agricultural heritages officially appeared in the No. 1 Central Document of 2016, and was again brought up as one of the major areas in the plans to build "green agriculture" and "ecological society" in the No.1 Central Document of 2018. The GIAHS project was uniquely positioned to facilitate the conservation of China's agricultural heritages.

The project was funded by the GEF and implemented by the FAO, and the Chinese domestic implementation was oversaw by the then Ministry of Agriculture. Project implementation (heritage status) was usually requested by the local municipal government, and supported by stakeholders from various levels, including the local communities, provincial and local departments of agriculture, the Institute of

Geographic Sciences and Natural Resources Research (IGSNRR) of the Chinese Academy of Sciences (CAS), and the Center for Natural and Cultural Heritage (CNACH) of IGSNRR, CAS.

The interventions at individual sites were developed around three main principles: dynamic conservation, adaptive management, and sustainable development. The values and livelihoods of local communities were at the core of all principles. Specific interventions can be categorized into three types: the first was ecological compensation, which was in place both horizontally between regional authorities and vertically between the local governments and higher-ups. The second was organic agriculture, in which the economic revenue generated by the traditional values, favourable agro-ecological conditions, and historical agricultural techniques of the heritage sites were targeted and strengthened by institutional arrangements and scientific research results. And finally, there was ecological tourism, in which economic revenue was generated by providing scenic getaways to the suburban population. All of these contributed to ensuring the conservation and sustainable management of the heritages sites by the local communities.

So far, the initiative has set up fifteen heritage sites in China, covering a wide spectrum of agricultural practices. These fifteen sites are: the Rice Fish Culture (2005), the Wannian Traditional Rice Culture (2010), the Hani Rice Terraces (2010), the Dong's Rice Fish Duck System (2011), the Pu'er Traditional Tea Agrosystem (2012), the Aohan Dryland Farming System (2012), the Kuajishan Ancient Chinese Torreya (2013), the Urban Agricultural Heritage – Xuanhua Grape Garden (2013), the Jiaxian Traditional Chinese Date Gardens (2014), the Xinghua Duotian Agrosystem (2014), the Fuzhou Jasmine and Tea Culture System (2014), the Huzhou Mulberry-dyke and Fish Pond System (2017), the Diebu Zhagana Agriculture-Forestry-Animal Husbandry Composite System (2017), the Xiajin Yellow River Old Course Ancient Mulberry Grove System (2018), and the Rice Terraces in Southern Mountainous and Hilly areas (2018).

The initiative, along with the Chinese domestic contributions, had successfully leveraged actions in the project sites and disseminated the values of GIAHS to the public. It also made public funding available to the project managers and stakeholders. However, post-project reviews have shown that despite the contributions by participating member states to develop and normalize the GIAHS initiative, the legal status of GIAHS remained unrecognized at the international level, and that the project failed to establish a reliable financing mechanism and institutional support for project upscaling. The Chinese cases, however, did show the importance of adopting a nationally important agricultural heritage system (NIAHS) framework, and how crucial

this framework would be for mainstreaming the GIAHS in national policies, regulations, and development plans. It also brings forward the necessity for specific funding to be allocated, either by the implementing state, such as China, or by the international coordinator, to support countries who are officially committed to the initiative.

### 3.3 Promoting farmland biodiversity

Similar to the previously described rationale for protecting the wild relatives of agricultural crops, the importance to increase species and genetic level diversity in farmlands has grown over the years in face of the changing climate, and has drawn much attention from the farmers, the scientific community, and the policy-makers. It has been a recognized fact that genetic level diversity of cultivated crops could increase population resilience to adverse effects such as pests and diseases. It, rather than the current widespread methods to combat pests and diseases such as the use of pesticides and biological methods, are often not limited by the economic, environmental, or legal concerns. The UNEP/GEF-supported project "Conservation and Use of Crop Genetic Diversity to Control Pests and Diseases in Support of Sustainable Agriculture" beginning in 2007 aimed to conserve and utilized farmland genetic diversity, and promote its application to the smallholders. Its goal was to enhance the conservation, use and knowledge of crop genetic diversity not only by farmers, but also by local and national scientific and policy institutions and ultimately to increase food security and improve ecosystem and human health. The project was largely in line with China's push to reduce chemical use during all aspects of agricultural production, and to promote human and environmental health and agricultural ecosystem functions. The six project target crops, rice (Oryza sativa), maize (Zea mays), barley (Hordeum vulgare), common bean (Phaseolus vulgaris), faba bean (Vicia faba), banana and plantain (Musa spp.), were major nutritional and economic crops for most developing countries, meaning that reforms in the production methodology could have considerable impact on the food and environmental safety conditions worldwide. Each of the participating countries, including China, Ecuador, Morocco and Uganda, contained areas of important crop genetic diversity for the selected crops. The overall intended results of the project were: one, to benefit rural populations in the project sites by increasing crop biodiversity and resilience to diseases and pests; two, to increase the genetic diversity of the targeted crops against pests and diseases; and three, to increase local stakeholder capacity and knowledge base so as to mainstream biodiversity measures in crop production.

The project was a globally coordinated effort that involved many countries in the process. The UNEP added to GEF's ability in project development, implementation, and evaluation, and also promoted country-level cooperation. Implementation in the

participating countries was oversaw by an international project management unit, who coordinated with the international steering committee in project guidance. At the country level, China had developed and implemented domestic policies, laws, and regulations to promote agricultural biodiversity conservation, not just for this single project, but also in coalition with other international projects or as part of the national development plans. The Chinese project team had also made appropriate linkages to existing projects and planned projects, such as with the previously mentioned UNDP/GEF project on "Conservation and Sustainable Utilization of Wild Relatives of Crops" and the UNDP/GEF project on "Multi-agency and Local Participatory Cooperation in Biodiversity Conservation in Yunnan's Upland Ecosystem".

The project had four key intervention aspects, which were: one, empirical evidence to support the spatial use of intra-specific diversity in agricultural production and farmland management when dealing with pests and diseases, the evidence would be the foundation for any stakeholders, such as farmers and local business, during their decision making processes; two, empirical evidence for the application of intra-specific diversity to combat pests and diseases, which include field trials and lab experiments to identify the best practices based on crop and disturbance types; three, knowledge base and capacity building for local stakeholders to apply intra-specific diversity measures to manage pests and diseases, which focused on the farmers' roles in adapting these methods in production; and four, mainstreaming the use of intra-specific diversity measures to manage pests and diseases at all levels of agricultural and environmental decision making processes. The goal here was to go further from the project findings towards global application. This required the development of clear and efficient means of dissemination.

Project outcome was mostly positive. Methodologies based on intra-specific diversity have been developed and applied to target crops. The Chinese partners have submitted their recommendations on the relevant practices to the policy makers in the agricultural and environmental sectors. Farmer associations were established and, with the support of research institutions and agricultural agencies, applied intra-specific diversity techniques to manage pests and diseases at the field level. Representatives, both male and female, from the local communities have participated in the decision-making process at various levels. Domestic project coordination committees have been set up to link up with other project-participating countries. Researchers and practitioners with detailed knowledge of the methodologies have been made available to local communities, and training programmes and demonstrations have been developed to facilitate knowledge distribution. The International Agrobiodiversity Training Centre has been established in Yunnan Agricultural University, Kunming, China to provide

training and demonstration to both domestic and international stakeholders. Policy briefs detailing the necessity and benefits of using intra-specific diversity measures to management pests and diseases have been drafted and submitted to policy makers at various levels, and were made available to all participating countries to facilitate the sharing of experiences.

This project included four participating countries: China, Ecuador, Morocco and Uganda, each with unique characteristics and substantial crop genetic diversity. Such a carefully designed multi-country structure offers invaluable opportunities for South-South cooperation, for capacity building and for producing results with broad applicability and replicability. The design and implementation of this type of global or multi-country projects should be further encouraged and facilitated.

Post-project evaluation had also generated certain recommendations, which were:

1. Another project phase should be approved and funded to fully materialize the previous projects research results, training, capacity building, demonstration and experiences.

2. The follow-up projects should include social scientists or ethno-botanists to explore the diversity potentials of local varieties and landraces, and to incorporate local and/or traditional knowledge into the process. The projects should also emphasize the identification and utilization of local knowledge and practices, with special interest on the participation of local farmers.

3. Future national projects should adopt management structures with only one clear coordinating institution.

4. The Project clarify in its on-farm work, how both inter-specific and intra-specific crop diversity affect pest and disease problems and how these may be linked by forging stronger ties during the next phase between this project and other on-going IPM programs and scientists who currently concentrate on inter-crop and inter-species diversity to control pest and disease damage.

### 3.4 Sustainable land and water management

One of the main issues surrounding China's agriculture production is the unevenly distributed water resources, particularly the naturally occurred difference between the dry-north and the moist-south of China. This has exacerbated the severity of land degradation and negative impacts to agro-biodiversity in regions susceptible to draught. The rapid development of agricultural production only made this problem worse, particularly in northern provinces that were also heavily dependent on agricultural

economy, such as those in the Huang-huai-hai and Northeast plain. The GEF funded project “Biodiversity Conservation and Sustainable Land Management in the Soda Saline-alkaline Wetlands Agro-Pastoral Landscapes in the Western Area of the Jilin Province” was a four-year project starting in 2012 dedicated to such issues. The project had identified the following two main factors threatening the sustainable development of agricultural ecosystems in those regions. The first was the unsustainable use of land and water resources by agricultural practices. The project specifically outlined the unsustainable use of water resources brought forth by underregulated irrigation and agricultural pollution, which would lead to long-term detrimental effects on biodiversity and ecosystem functions. The second was climate change, which could exacerbate the existing issues in an unprecedented manner. China is going into an era with drastic changes in both economic and social aspects, the historically unattended environmental burden requires immediate attention.

The project was funded by the Food and Agriculture Organization (FAO) with GEF as partner. A pilot site in Jilin Province, China was identified for implementation. A cooperation of a number of agencies and departments were involved in the process. The Jilin Provincial Government Legislative Affair Office was responsible for legislative affairs and regulation processes, making it possible for any new regulations and/or laws to be adopted by the regional government. The Ministry of Water Resource (MWR) was responsible for constructing the sustainable water consumption infrastructures. It was also in charge of water conservation regulations and laws at various levels, the implementation of which oversaw by the regional and local Departments of Water Resources. The Ministry of Agriculture coordinated between the various stakeholders in need of the managed land and water resources, and ensured the implementation of actions fitting the sustainable land and water use models. They were also responsible for providing demonstration and capacity building to the local farmers to facilitate their continuous involvement. The Ministry of Land and Resources was responsible for land inventory, zoning, and planning. They were also in charge of land use regulations. The Ministry of Environmental Protection (later became the Ministry of Ecology and Environment) at its agencies at various levels were responsible for formulating and implementing conservation laws and regulations. Other agencies and institutions include the the various levels of science and technology departments and associations, the Hadashan Hydro Program Administration (HHPA), and the Chagan Lake Natural Reserve Administration (CLNRA) that was established specifically for the sustainable use of land and water resources in the region. With the help of these multilevel authorities and agencies, an integrated model for Sustainable Land and Water Management (SLWM) was implemented to address the need for sustainable agricultural production and resources consumption, two specific interventions were in

place, one was the sustainable design and application of the irrigation system, the other was the adoption of ecological agricultural practices to meet conservation needs.

Post-project evaluation showed that after four years of sustainable model implementation, the expected outcomes were mostly met. The SLWM model was successfully adopted in three counties, and facilitated adjustments in policy, legislation, and regulation in the project areas to support the implementation of the SLWM model and relevant sustainability practices. Practitioners from local communities

The level of inter-agency cooperation among the different levels of authorities, stakeholders, and institutions had often resulted in a gap or overlap of the roles and responsibilities these different parties had. A project steering committee was in place to facilitate such cooperation, still miscommunication often took place during the developing and implementing of the regulations and interventions. And even though China has had a comprehensive legal framework for the sustainable use of land and water resources at various levels, the top-down approach usually resulted in gaps in landscape level interventions. Some of the major constraints identified during the project were as follows: firstly, the fragmented policies and regulations generated gaps between the various conservation agendas and interventions, which were problematic for an integrated land and water conservation model at the field scale. Regulations and policies tended to overlook field level actions that were in fact more influential to the local ecosystems and community livelihoods. This was aggravated during project implementation due to the difficulty in coordination among the various authoritative agencies both horizontally and vertically. Secondly, the lack of efficient and continuous supervision and monitoring frameworks, partly due to the issues in facilitation among the different agencies, resulted in suboptimal implementation of interventions at the local scale. Thirdly, the conflicts of interests between, and sometimes within, the local stakeholders and the policy-implementing agencies. While a common objective was sought after, stakeholders often took different approaches in using land and water resources, which usually led to clashes at the local scale. In a top-down project like this, the government was in a unique position to facilitate the different interests among the stakeholders, which should be emphasized in any future endeavours. Fourthly, since this was a project that systematically modelled the use and allocation of natural resources, regional protectionism was often found to be influential. National and provincial level policies and directives were at times ignored or even purposely distorted for regional gain. Better facilitation based on empirical evidence, rather than top-down directives, might be more effective in dealing with such issues. Finally, the neglected local voice in the developing and implementing of relevant conservation

policies in the region. This prompts an increased participation of local communities and stakeholders in the policy-making process at various levels.

# Interventions in the fishery industry

With the fast development of the Chinese fishery industry, the main concern over future development has changed to the need to produce safe and high-quality products sustainably with minimal environmental and ecological impacts. This continuous misalignment between consumer demand and the suboptimal supply side structure requires increased institutional arrangements and regulations to be established and enforced. As in any domestic industry, Chinese fishery development has been regulated by policies and developmental agendas set by the central government. Since 1978, there have been three main successive goal steering the policies and regulations of the fishing industry, these were the economic development and food supply, the development of "blue economy" and the "go global" strategy, and the environmental protection and the establishment of ecological society (Chen et al., 2017). Several policies and regulations have been established in response to the sustainability requirements since the late 1990s, and can be loosely divided into five categories, including the control of fishery input and output, technical regulations, ecological practices, and economic incentive. Since most of these fishery policies and regulations were developed and enforced by fishery authorities under the guidance of the central government and the Ministry of Agriculture (now Ministry of Agriculture and Rural Affairs), they have been summarized together in one section.

# 1. Input and output management

These have targeted the resources and means of production inputted into the fishing industry, and the output being exported. The main ones are listed as follows:

### 1.1 The fishing licensing system

This was outlined in the "Fisheries Law of the People's Republic of China" (passed in 1986, current version amended in 2013). Relevant fishing licenses were to be approved and distributed by matching levels of the fishery authorities. The licenses were not to be traded, rented, or altered in any way. Only those with approved fishing licenses can practice fishery at designated areas and seasons.

### 1.2 The fishery boat buyback and the vessel power control practices

The buyback practices began in 2002 aimed at reducing the number of fishery boats operating at sea. Until 2014 it had successfully bought and reduced commercially operated fishery vessels by 31%. However, even with these practices in place, the total tonnage of fishery vessels had increased by 20% from 2002 to 2014, with average increment of fishing haul at 1.6% per annum (Cao et al., 2017).

### 1.3 Fishery personnel re-employment programme

This was a state-level initiative to allocate fishery practitioners to other sectors of the fishing industry. But little was gained despite the time and resources spent on this initiative. While total employed practitioners dropped by 7% from 2003 to 2014, the total number was still over one million, and the number of traditional fishing practitioners was still above three million (Cao et al., 2017).

### 1.4 Closed fishery seasons practice

This major reform was approved by the State Council of China (SCC) in 1995, and was built on previous regulations such as the 1979's "Regulations on protecting marine resources" issued by the SCC. This regulation categorically prohibits all fishing vessels from operating in designated seasons each year. However, seasonal prohibition had usually resulted in aggressive over-haul afterwards, thereby counteracting the benefits achieved by this practice (Shen and Heino, 2014). Moreover, fishing practitioners would have to seek alternative livelihood sources during the prohibition seasons, this significantly increased their economic burdens, making this policy unsustainable by itself.

### 1.5 Marine protective areas

Based on the "Regulations of the PRC on natural reserves" (Ministry of Environmental Protection, 1994), and the subsequent guidelines for the management of marine natural protected areas in 1995, marine natural protected areas have been set up to protect marine ecosystems and biodiversity. However, of the 49 oceanic natural reserves in place, only less than 10% that were designated "non-fishing zone" received proper attention (Marine Conservation Institute, 2019). There were also 51 Marine Species Reserves and 22 Marine Special Reserves established (State Council of China, 2019), but the conservation practices and ecological effects of these practices remain to be seen.

### 1.6 Total allowance catch system

The 2000 amendment to “Fishery Law” added the total fishing allowance catch quota, putting a cap on the allowed total marine catch in a given time frame. However, due to lack of a monitoring system and institutional gaps, this regulation has not yet been implemented in the domestic waters.

### 1.7 The Zero and negative-growth targets

These regulations were implemented to further control the marine catch allowance. The Zero-growth target was instigated by the then Ministry of Agriculture in 1999. It soon developed into the negative-growth target and was implemented in 2000. These regulations marked the nation’s dedication to apply stringent measures to control marine total catch and to use marine resources sustainably. As a result, total marine catch held steady between the years 2000 to 2009, and the 20% increase to domestic fishery was mostly attributed to the growth of aquaculture (Cao et al., 2017).

### 1.8 The double-control policy framework

This was a framework targeting both input and output in the fishing industry outlined in the “Notice on Further Controlling the Number of Fishing Boats and the Management of Total Marine Fishery Resources” in 2017 (Ministry of Agriculture, 2017). This was in coordination with the goals of the central government and the state council to promote balanced economic, political, cultural, social, and ecological progress, and with the requirements laid out by the “Integrated Reform Plan for Promoting Ecological Progress” as set by The Communist Party of China (CPC) Central Committee and the State Council of China (SCC). The two most important specific targets were: one, to control the total number of fishing vessels, reduce the total number by 20,000, total power wattage by 1.5 million kw by the year 2020; and two, to reduce the total marine catch to below 10 million tons by the year 2020.

## 2. Technical measures

These were measures to regulate the catching process, including the minimum mesh size of fishing nets, minimum catch size, prohibition of destructive fishing methods, and the catch limit of juvenile fish. These measures directly contributed to the conservation of marine wildlife communities. But to this date, comprehensive data on the ecological and conservation effects of these measures on domestic marine wildlife conservation is still scarce.

# 3. Ecological initiatives and practices

### 3.1 Marine repopulation programme

Repopulation or rewilding programmes began in mid-1980s as direct actions to boost marine wildlife resources and maintain sustainable population dynamics. These can be publicly driven or as part of the compensation provided by businesses who were involved in marine development and constructions potentially threatening marine wildlife. The most noticeable of the early actions was the 1984's repopulation of shrimps (*Fenneropenaeus chinensis*) in the Bohai Gulf (Shan et al., 2012; Wang et al., 2006). Records show that up until 2008 there have been over one hundred species repopulated through the programme (Shan et al., 2012). However, not enough evidence has been produced regarding the ecological effects of these activities.

### 3.2 Habitat restoration.

This include the construction of artificial reefs and natural habitat restoration measures, both aimed at providing habitat to support marine communities. Like repopulation, this can also be publicly driven or as part of any ecological compensation programme of fishery enterprises.

# 4. Economic measures

Economic measures include marine resources compensation programme, marine resource restoration fee programme, and fishing vessel construction and fuel subsidies. Intended to promote fishery livelihoods, these subsidies had complex effects on the industry. The then Ministry of Agriculture, along with the Ministry of Finance, made adjustments to the fisheries subsidies to promote sustainable use of marine resources in 2015, laying out plans to reduce fuel subsidies by 60%, from 3.7 billion USD in 2014 to 1.5 billion USD in 2019 (Ministry of Finance, 2015). The intended goal was to reduce total number of marine fishery vessels. The government also provide subsidies to encourage distant water fishing (DWF) to meet market demands while conserving domestic resources, but the ecological effect of this practice is debatable (Cao et al., 2017).

Though most of the abovementioned policies, regulations, or progarmmes set out to directly conserve marine resources and promote biodiversity, their efficacies were somehow questionable (Cao et al., 2017). Policies such as seasonal fishing, spatial protection, and growth targets did not fully take into account the biogeographical

characteristics of marine communities, and were not support by a reliable monitoring system. Meanwhile, most of these policies and regulations were top-down approaches, but the implementation of which rely on the continuous enforcement of local authorities. Local governments were often attracted by economic incentives that were contradicting the overall sustainability goals, leading to suboptimal monitoring and regulative practices in the local level.

## Sustainable animal husbandry policies and interventions

Driven by population demand and consumer change, China's domestic animal husbandry number had almost tripled, increasing from 142 million livestock units (LUs) to 441 million LUs from 1980 to 2010 (Bai et al., 2018). This has significantly raised resources depletion rates and increased the environmental burdens of agricultural ecosystems. According to the "First Census Report of Domestic Pollution Sources" released in 2010, pollution from the animal husbandry industry, such as greenhouse gas (GHG) and livestock excrements, have become one of the major sources of domestic pollution (Ministry of Ecology and Environment et al., 2010). These pollutants not only contaminated rural environments, but were also carried to and affected other ecosystems by surface and underground water, threating environmental and human health at much larger scales.

Anticipating the future requirements on the animal husbandry industry, the Chinese government has instigated a number of policies and regulations promoting its sustainable development. In 2007, the State Council of China issued the "Opinions on Promoting the Healthy and Sustainable Development of Animal Husbandry", listing, for the first time, environmental protection, cleaner production, resource conservation, and the transformation to ecological animal husbandry practices as some of the main goals of future development (State Council of China, 2007). Similar policies have been produced at each stage of the domestic economic development, some of the most important ones are listed as follows.

## 1. Conserving livestock and poultry genetic resources

Animal genetic resources is not only an integral part of the total biodiversity, but is also closely related to the agricultural ecosystem functions and human livelihood. The "Conservation and Sustainable Use of Livestock and Poultry Genetic Resources" was a national level initiative in close link with the CBD agendas. In October 2005, "Animal Husbandry Law of the People's Republic of China" was passed, listing the regulations for conserving livestock and poultry genetic resources as one of the main goals (Central

People's Government of PRC, 2005). The regulations outlined a framework to establish institutional arrangements to continuously monitor genetic diversity conditions and utilize public and private resources to conserve genetic diversity. This initiative was implemented in the form of laws designed to protect and sustainably harvest the genetically representative or unique biological resources. Relevant legal framework received regular updates, the latest being in 2016 in coordination with the Thirteenth Five-year Plan (Ministry of Agriculture, 2016). The updated framework listed 159 species to be protected at the state level and 260 at the provincial level. Established facilities included 158 National Livestock and Poultry Genetic Resources Protection Farms, 23 National Livestock and Poultry Genetic Resources Conservation Areas, and 6 National Livestock and Poultry Genetic Resources Banks. The implementing agencies has also been in close contact with international initiatives such as the FAO's livestock and poultry genetic resources conservation talks.

Future goals of the initiative include strengthening the framework for conservation and sustainable used of genetic resources, and facilitating the establishment of an effective monitoring system. Specific targets as laid out by the Ministry of Agriculture and Rural Affairs included increasing conservation effectiveness of state-level species to above 95%, and provincial level species to over 80%.

## 2. Animal husbandry pollution standards

Non-point source pollution from agricultural production has been identified as one of the main factors threatening the sustainability of soil and water resources in agricultural ecosystems, and pollutants released from animal husbandry were among the top sources (Zhang et al., 2004). As part of the national initiative to control non-point source pollution and to promote sustainable agricultural practices, the "Discharge Standard of Pollutants for Livestock and Poultry Breeding" was implemented in 2001, and updated in 2003, to regulate and control pollutant discharges along the production chain (Ministry of Ecology and Environment, 2003). The standard listed requirements for the discharge of wastewater and odor, and regulations guiding solid waste treatments. As a technical guide and policy supplement to the general framework, the Ministry of Ecology and Environment issued the "Policy for Pollution Control in Livestock and Poultry Industry" as a guide and foundation for pollution control, environmental assessment, and industry operating protocols (Ministry of Ecology and Environment, 2010).

This was a passive framework that required continuous monitoring and enforcement from local authorities, therefore the effectiveness of implementation would be spatially

inconsistent. Currently, empirical evidence is lacking for the national level effectiveness of the framework and the ensuing environmental impact. We do know, however, that the framework mainly targeted scaled production and not household level practices (Ministry of Ecology and Environment, 2010). Given the fact that household level practices are a major part of the domestic livestock and poultry industry, it is difficult to say to the total effectiveness of the framework. Studies have shown that the development of specialized household level livestock and poultry production has led to significant environmental pollution (Su, 2006). As such, scholars have recommended more stringent measures of pollution control and monitoring systems, with particular focus on specialized household level practices (Chou, et al., 2013).

## Potentials for the TEEB framework

The economics of ecosystem and biodiversity (TEEB) aims to monetize the economic benefits of biodiversity and ecosystem services, and to incorporate market forces in facilitating the decision-making process and the link between science, policy, and economic instruments.

While the Chinese government has recognized the intrinsic and external values of biodiversity and ecosystem services, and has incorporated the ideology that "lucid waters and lush mountains are invaluable assets" into the core principles of the nation's green development agendas, we could still identify gaps between the current interventions and the possibilities as outlined by the TEEB framework. The most important one being the level of resources mobilized. Most of the interventions listed in this report were top-down approaches initiated by the central government or inter-governmental organizations, facilitated by relevant ministries, and implemented by subordinate agencies or local authorities (Table 1). As such, while they excel in enforcement, reach, and continuance, they often lack in mobilization and adaptability. As TEEB attempts to present a quantifiably valued ecosystem to the general audience, it could utilize new market devices reaching a range of potential stakeholders across disciplines (Ring, et al., 2010). An active participation from the bottom up could potentially tap into stakeholder resources new to the arena, and bring together players from all aspects of the discipline by bridging their differences of understanding. At the same time, market-driven actions are far more adaptable to spatial and temporal variations than top-down approaches, meaning that regional conservation practices could tailor to their own developmental agendas.

Potential applications could be useful in multiple cases as stated in the report. In summary, most interventions could benefit from the TEEB framework because of its

two unique characteristics. The first is the framework's outreach potential. Interventions such as the protected area initiative and Grain-for-green project were often unable to quantify non-use ecosystem benefits to the general audience, especially to residents in and around the project areas whose lives have drastically changed due to the processes. The TEEB framework offers us a tool to monetize conservation practices to this particular group of people who would otherwise not be able to fully grasp the importance because they were either ill-informed or unfamiliar with the subject. If outreach were to be conducted following the TEEB framework, the projects could potentially attract participants and financiers interested in, or would otherwise benefit from, the environmental improvements. This would ease the financial burden on the government and mobilize social forces to participate in the ecological restoration process.

The second is the framework's economic perspective towards ecosystems. Interventions that involved eco-compensations were often criticized because they applied certain universal compensation standards across different regions. Therefore, compensation was unable to reflect regional differences and were thus likely to generate uneven conditions that favoured some regions while neglecting others. Similarly, we could often find miss-matches between the central government's goals and regional governments' efforts in ecological interventions as national-level projects sometimes puts insufficient consideration on local interests in the process. The TEEB framework offers unique monetary perspectives in evaluating and quantifying the ecological processes and the economic benefits, from which quantifiable assessments would be made that could inform the higher-level policy makers of the specific compensations or actions necessary. Successful implementation of the framework could support the development of regional-specific compensation standards, and considerably add to the local adaptive capacity, and in turn promote effective local participation.

Strict protection is far from suitable in today's economic setting, an effective conservation strategy is one combing the conservation and sustainable use. The TEEB framework can link these two categorically different aspects that were once difficult to quantify and thus hard to balance. Since any successful conservation requires lengthy and continuous actions, maintaining balance between conservation and economic development is key in ensuring future success.

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