

Perspective on Improving Landscape Managements for Biodiversity Conservation and Sustainable Production in China

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1 Challenges for sustainable production in China

In last decades, China has achieved steady increasing in agricultural production, providing sufficient food for 21 per cent of the world's population and keep high level of food self-sufficient rate of more than 95%. This achievement also greatly reduced the prevalence of undernourishment and contributed to global hunger reduction^[1].

Unfortunately, the increasing in food production in China was companied with increasing inputs of agricultural chemicals and water resources consumption. The utilization efficiency of these agricultural inputs were much lower than developed country, which resulted in serious resources and environmental crisis, including water shortage, pollutions of soil, water and air, and also soil degradation. More and more evidences indicated environmental pollution and resources shortage had become the bottleneck for further improvement in food production in China.

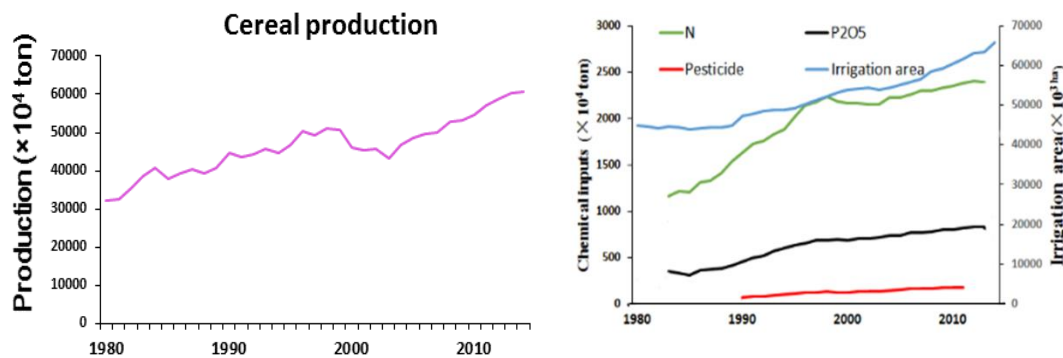


Fig. 1 Cereal production and agricultural inputs in China from 1980-2014

Meanwhile, food demands in China is continually increasing and will be reach to 0.64 billion ton per year, as the population will keep increasing and reach 1.4 billion up to 2020^[2]. In contrast to increasing in population and food demands, the arable land is gradually decreasing in recent years due to urbanization.

Furthermore, the limited agricultural natural resources are also the great challenge for the sustainable production in China. Farming land per capita in China is only 1.39mu (<0.1Ha.), less than 40% of the world average and the water per capita is 2300 cube meters, about ¼ of World average. These resources were unevenly distributed: arable lands are mainly distributed at the Eastern China but scare in the Western China: water resources are abundance in the Southern China but scare in the Northern China. However, rapid urbanization and industrialization in the Eastern and the Southern China took away lots of fertile arable land. Alternatively, the crop sowing area in Northwestern, Northeastern and Northern China presented gradually increasing. Over exploitation land in these areas in Northwestern, Northeastern and Northern China has great risk of ecological degradation.

Loss of biodiversity and the associated ecological services in agricultural landscape is another challenge for food production. Although remarkable efforts, such as establishment natural reserves, conservation and adaptation of traditional agricultural practices and formulation of laws and regulations aimed at the conservation of biodiversity, have been undertaken to alleviate the negative impacts of intensive agriculture, many measures were limited in scope and felt to be insufficient in conserving the overall biodiversity in the Chinese. Loss of genetic and crop diversity, degradation of wetland and grassland ecosystem and simplification of agricultural landscape were common.

In addition, China is a country with frequent natural disasters. We can easily found the strong effects of natural disaster on the food production in last decades. And the global climate change is expected to exert additional risk for sustainable production in the future.

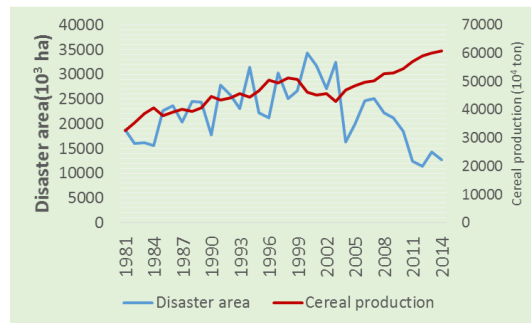


Fig. 2 Disaster area and cereal production in China from 1981-2014
(Data source: National Bureau of Statistics of the P.R. China)

Therefore, a new agricultural strategy is called to produce more food with less resources cost, to avoid further loss of natural land, to reduce dependence on non-renewable resources such as chemical inputs, and to be more stable and resilient to environmental change.

2 Biodiversity: a solution for sustainable production

Broadly speaking, biodiversity can be defined as the diversity of gene, species, ecosystem, and landscape. In recent years, biodiversity was more and more concerned as a solution for sustainable production and food security, because it provides the solution for current challenges in agricultural production.

Biodiversity can improve productivity by providing the building blocks for new productive crop varieties or animal varieties. Diversified cropping system, like intercropping and rotation, enable more efficient utilize of land and other resources like light and water. It also provides the solution for erosion prevention, cleaning water and air, and micro-climate regulation. And high species diversity increases functional complementarity due to niche differences, increases functional redundancy under environmental change, and increases functional insurance value under global change [3-4]. High landscape diversity may guarantee resilience, the capacity to reorganize after disturbance [5]. More importantly, biodiversity is associated with ecological services, such as biological control, pollination, soil formation and nutrient cycling, which could be replacement of anthropogenic inputs and/or enhancement of crop productivity [6].

3. Biodiversity Conservation and Food Production : the conflicts

Globally, to meet this increasing food demand with current agricultural production methods, it was estimated another one billion hectares of natural habitat should be converted to agricultural production primarily in the developing world, which harbors most of diverse species in the world, indicating more threatens to biodiversity [7]. On the other hand, the increased demand for ecosystem services calls for more effective conservation of biodiversity [8-9]. Similarly, China is also facing the great pressure of increasing arable land and ecosystem services to satisfy ever increasing food demands and welfare requirements. Therefore, it is necessary to take measures to reconcile the conflict between food production and biodiversity conservation.

4. Landscape managements to reconcile biodiversity and sustainable production

It is essential develop landscape management to conserve biodiversity and to harness the biodiversity associated ecosystem services for sustainable production because : 1) species experience their surrounding landscape at different Spatial scales; 2) Structurally complex landscapes can enhance local diversity in agroecosystems, which may compensate for local high intensity management; 3) The efficiency of local biodiversity management would be affected by the complexity of the surrounding landscape [3][10].

Landscape managements could include pattern oriented and process oriented approaches [11].

Pattern oriented approach refer to approaches to improve or restore complexity of landscape composition and configuration, conservation or restoration of habitat. The approach is mainly aimed to conserve or improve the habitat quality and suitability for species persistence in agricultural landscape.

Process oriented approaches refer to optimize farming practices at landscape level, or conserve key species or functional groups for important ecological process, such as biological control, pollination, nutrient cycling.

Table 1. Example of landscape management approaches to reconcile biodiversity and sustainable production ^[11-12]

Approach	Specific measure	Benefits
Pattern oriented approach	Increase structural diversity	Pest suppression
	Genetic diversity in monoculture	Disease suppression, increase production stability
	Diversify field with non-cropping elements, such as grassy strip, beetle bank, wild flower strip, field margin	Pest suppression
	Crop rotation: temporal diversity through crop rotation	Disease suppression, increase production
	Polyculture, growing more than one crop species within the same field	Disease suppression, climate change buffering, increase production
	Agroforestry: growing trees and crops together	Pest suppression, climate buffering, increase production
	Diversify landscape: development of landscape with multiple ecosystem, with complex composition of cropping system and non-cropping system, develop complex configuration of cropping elements and non-cropping elements at landscape level	Multiple function, including increase biodiversity, suppression pest, climate regulation, landscape conservation, cleaning water etc.
Process oriented approach	Optimize farming practices to avoid over use of fertilizer, pesticide	Reduce agricultural pollutants to favor biodiversity without loss of production
	Apply wild friendly farming, such as organic farming	Reduce agricultural pollutants to favor biodiversity with certain loss of production
	Developing integrate planting and animal production	Reduce agricultural pollutants , promote recycling use of resource, increase production
	Conserve or manage key species, such as pollinator and natural enemy, in agroecosystem	Utilize biodiversity to promote production
	Manage soil fertility and soil biodiversity	Increase production, carbon sequestration, suppress crop pest and diseases

4. Improve landscape managements in China for biodiversity conservation and sustainable production

In order to improve biodiversity conservation and sustainable production, we suggested landscape managements should be strengthen from followed aspects in China:

4.1 Improve biodiversity conservation at agricultural landscape

As one of the first countries to ratify the Convention on Biological Diversity (CBD) in 1993, China has initiated a series of steps and measures to fulfil the obligations under this convention. As statistical data indicated, the number of natural reserves was gradually increased in last decades. However biodiversity conservation in main agricultural production area are largely neglected. More special biodiversity conservation scheme in agricultural production region, such as conserve or restore semi-natural land, encourage the establishment of ecological infrastructure, encourage less intensive managed (organic farming) or extensive managed farming in main agricultural production area, should be developed to encourage better conservation of biodiversity and sustainable production. Practically, ecological infrastructures, such as beetle banks and wild flower belts, which are favor natural enemies and pollinators, should be widely encouraged.

4.2 Promote crop diversity at landscape level

Although increase of semi-natural land and ecological infrastructure are important for maintaining biodiversity and increasing production, increase of semi-natural land and ecological infrastructure is expensive and it means reducing arable land. It is less possible in China to set large amount of arable land side for ecological purpose only in consideration of the limited arable land and huge food demands in China, and also huge demands of financial subsidy. Promotion of crop diversity would be an alternative way to promote diversity without loss of production in agricultural landscape ^[13-15], and also the potential way to promote pest/disease control and nutrient use efficiency ^{[16-}

^{17]}. Although China has a history of intercropping, agroforestry, rotation, simplified cropping system would become the main trends in the nearly future, because of more and more people rush into the city and decrease of labors. Policy to encourage the diversification of cropping systems at landscape level is therefore urgently needed.

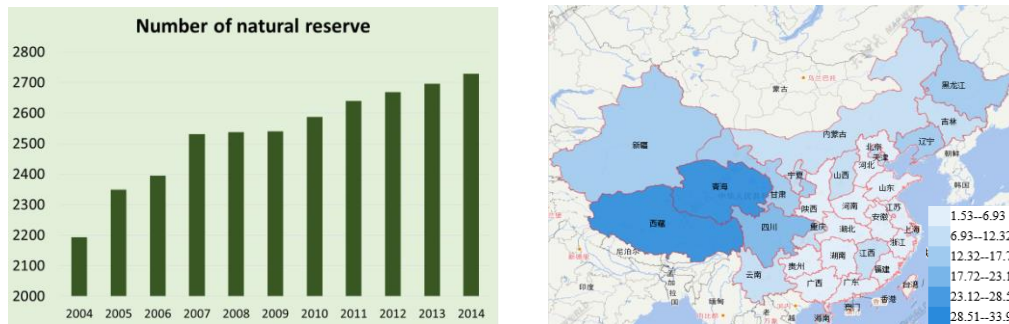


Fig. 3 Number of natural reserve in China (2004-2014) (left) and provincial area proportion of natural reserve in China (right)

4.3 Adapting land use to resources and environment

Modern agricultural production techniques enables agricultural production with less constraints of local resources and environment. However, production without adapting to local resources and environment is always the sources of environmental crisis. For example, land reclaim in the Northern of China accelerates the regional desertification, while the land reclaim in the mountainous region lead to series soil erosion, or even worse to lead to stony desertification in the Southwestern China. Recently, replacement of soybean plantation by rice cultivation in the Northeastern China resulted serious problem of soil degradation. Adapting cropping system to local climate, soil, topographic condition should therefore be more concerned.

4.4 Optimizing land use intensity at landscape level

According to the National planning for agricultural sustainable development (2015-2030), China was divided into zones with different development levels. Ecologically vulnerable areas in the west, including Tibet and Qinghai province, are planned as conservational developing region, while the Northeast and the Eastern China were planned as priority developing zone. This planning given a general guidance for regional development intensity. However, more specified land use intensity and management planning still needed. Agricultural management planning should provide guidelines for regional optimized crop management, including guidelines for fertilization, irrigation, tillage, etc. based on crop needs, soil nutrient availability, water resource availability, climate characteristics, topographical and geographical location (such as slope or location in the watershed), etc. ^[18-20]. For example, infertile soil should be considered to have more extensive planting or fallowed as ecological land; land located at ecological sensitive zone should be transform into ecological use; fertilization dosage should be adjusted according to soil futility; rotation or intercropping with leguminous crops should be encouraged to sustain the soil fertility.

4.5 Applying engineering approaches to improve or restore land productivity

Degraded land and low fertility land account for consideration areas in China. Ecological restoration is an important measure to reverse human-induced environmental degradation, and it is especially widely implemented to improve biodiversity restoration and improve production all over the world ^[21]. In Northern China Plain, ecological restoration has also been successfully applied to reform natural infertile land. For example, in the 1970s, successful engineering measures were applied to reduce the high level of soil salinity in one of the most important cereal production areas in China ^[22] – the North China Plain –and greatly increase wheat yield and biodiversity in the region. Today, ecological restoration is still potentially efficient ways to improve soil productivity, particularly when large amount of soil are facing the problem of degradation after decades of intensified production in China.

4.6 Design of Integrated Planting/Animal-Farming Cycling System

In an integrated planting/animal system, crop residues can be used for animal feed, while animal and animal by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, thus reducing the use of chemical fertilizers. Short of recycling use of crop residues and animal waste is the important reason of agricultural pollution. However, separation of planting industrial and animal production industrial in space is common in China. Integrating planting industrial with the animal industrial at landscape level or administrative level should be further improve in the nearly future.

4.7 Conserving arable land: both quantity and quality

The last but not least is to conserve the limited arable land resources. China had launched a very strict Arable land red-line policy to require minimum of 1.8 billion mu arable land should be conserved. However, driven by the rapid urbanization, another policy-Arable land dynamic balance policy, was applied, which require the loss arable land should be compensate by same area of reclaimed arable land. This resulted in the loss of natural and semi-natural land and also the replacement of fertile land by infertile land, and also further resulted in the detrimental to biodiversity and the associated ecological services, and also land productivity. Therefore, the arable conservation should not only cover quantity conservation but also quality conservation. Particularly, soil fertility and semi-natural land in the landscape context, should be integrated into the arable land conservation as two important standards of arable land quality.

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