# The Ecological Service Function Development of Urban Modern Agriculture in Tianjin City and Corresponding Countermeasures

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**Abstract**   Based on the current situation of ecological environment of agriculture in Tianjin City, we divide the ecological service function of urban modern agriculture in Tianjin City into seven types: air regulation, climate regulation, water conservation, soil formation and protection, waste disposal, biodiversity conservation, and ecological entertainment. According to the method for assessing the value of natural ecosystem, coupled with the ecological service value equivalency factor table of China's ecosystem formulated by domestic scholars, we estimate the ecological value in Tianjin City. The results show that the actual ecological value of agriculture in Tianjin City was 30.752 billion yuan in 2010, close to the agricultural economic value (31.733 billion yuan) in 2010. Finally we put forth the following countermeasures for the ecological function development of urban modern agriculture in Tianjin City: strictly protecting arable land, and raising the standards of compensation for agricultural land requisition; actively and prudently developing facility agriculture, and preventing the blind scale expansion of facility agriculture to better give play to its ecological function; strengthening the construction of ecological agriculture, and promoting the market conversion of the ecological service value of agriculture; improving the environment, to form relatively complete agro-ecological system.

**Key words**   Tianjin City, Urban modern agriculture, Ecological services, Ecological value estimate

The relationship between agricultural development and ecological environment protection is both mutually-promoted and mutually-restrained. Therefore, the agricultural development must pay attention to the protection of the ecological environment. Urban modern agriculture is developed modern agriculture, with economic function, ecological function, and socio-cultural function[1]. Among them, economic function is the most basic productive function; ecological function and socio-cultural function are the non-productive functions. Due to the externality and public goods property of the non-productive function, for a long time, the main objectives of agricultural development have always been focused on the economic benefits, and the value of non-productive function has not been included in the agricultural income, often ignoring the ecological benefits. With the expanding range of urbanization, people's requirement of the environmental quality is intensifying; developing ecological agriculture to protect and improve the ecological environment, prevent pollution and maintain ecological balance, has become the important content in the construction of modern agriculture. Discussing, estimating and developing the ecological value of agriculture in Tianjin City, is of great significance to the construction and development of urban modern agriculture.

# 1   The ecological function type of urban modern agriculture

Based on the requirements of the development of coastal urban

modern agriculture, the main problems facing the coordinated development of urban modern agriculture and ecological environment in Tianjin City, and the general awareness of the agro-ecological utility at present[2-3], we mainly divide the ecological service function of agriculture in Tianjin City into 7 types (air regulation, climate regulation, water conservation, soil formation and protection, waste disposal, biodiversity conservation, ecological entertainment), as is shown in Table 1.

# 2   Ecological value estimate of urban modern agriculture in Tianjin City

Using the method for assessing the value of natural ecosystem[4-5], according to the ecosystem services function and type of urban modern agriculture in Tianjin City, we select the agricultural ecosystem values (air regulation, climate regulation, water conservation, soil formation and protection, waste disposal, biodiversity conservation, ecological entertainment) as the indicators for measuring.

## 2.1   Calculation method of ecological value of agriculture

Measuring of the ecological value is on the basis of the economic value of ecological services. According to the basic principles for the measuring of the ecological value of agriculture, we can use the ecological service value equivalency factor for assessment and measuring[6]. The ecological value equivalency factor of ecosystem refers to the potential capacity of ecological services produced by the ecosystem, defined as the economic value of annual food yield produced by 1 $hm^2$ of farmland with the national average yield. Based on this, we can convert the weight factor table into the unit price table of ecosystem services in the year. The ecological value equivalent per unit area of agro-ecological system in China is shown in Table 2.

**Table 1   The ecological function type of urban modern agriculture in Tianjin City**

| Ecosystem services | Ecosystem function | Example |
|---|---|---|
| Air regulation | Regulation of atmospheric chemical composition | $CO_2/O_2$ balance, $O_3$ anti-ultraviolet |
| Climate regulation | The process of adjusting the temperature, precipitation and the participation of living creature | Regulation of DMS (dimethyl sulfate) product arising from the impact of greenhouse gas on cloud |
| Water conservation | Regulation of the flow, storage and maintenance of water | Water is provided by watershed, reservoir and underground aquifer |
| Soil formation and protection | Soil formation, nutrient cycling, gene control | Rock weathering and accumulation of organic matter; fixing of nitrogen, phosphorus and potassium; the cycle of other elements and nutrients |
| Waste disposal | The removal or degradation of excess or heterogeneous nutrients and chemical compound | Pollution control, detoxification |
| Biodiversity conservation | Pollination, biological control, habitat, genetic resources | Movement of flowering plant gametes; dynamic nutrition regulation of biological population; provision of habitat for settling and migratory population. |
| Ecological Entertainment | Provision of opportunities for leisure and tourism activities | Eco-tourism, outdoor recreation activities |

**Table 2   The ecological value equivalent per unit area of agro-ecological system in China**

| Ecological function | Arable land | Forest land | Grassland | Water area |
|---|---|---|---|---|
| Air regulation | 0.50 | 3.50 | 0.80 | 0.00 |
| Climate regulation | 0.89 | 2.70 | 0.90 | 0.46 |
| Water conservation | 0.60 | 3.20 | 0.80 | 20.38 |
| Soil formation and protection | 1.46 | 3.90 | 1.95 | 0.01 |
| Waste disposal | 1.64 | 1.31 | 1.31 | 18.18 |
| Biodiversity conservation | 0.71 | 3.26 | 1.09 | 2.49 |
| Ecological entertainment | 0.01 | 1.28 | 0.04 | 4.34 |

It needs to be noted that the water area in Tianjin City is vast, but the area of water body here is only limited to the fishery area for agriculture.

Having a look at the industrial structure in Tianjin City, for a long time, the share of agricultural output value in the economic aggregate is small. Given that the current urban development has a more urgent demand for agricultural ecology, we determine that the economic value of one value equivalency factor of ecological services is equal to the national average market value of grain yield per unit area in the current year. Given that the current urban development has a more urgent demand for agricultural ecology, we determine that the economic value of one value equivalency factor of ecological services is equal to the national average market value of grain yield per unit area in the current year. Thus, we can calculate the national average unit price of ecological service value of ecosystem. The calculation formula is as follows:

$$E_a = \sum_{i=1}^{n} \frac{m_i p_i q_i}{M} \qquad (1)$$

where $E_a$ is the value quantity of unit equivalent factor (yuan/$hm^2$); $i$ is the food crop type; $p_i$ is the national average price of food crop $i$ (yuan/kg); $q_i$ is the yield per unit growing area of food crop $i$ (kg/$hm^2$); $m_i$ is the growing area of food crop $i$ ($hm^2$); $M$ is the total growing area of n food crops ($hm^2$).

On the basis of obtaining the value quantity of unit equivalent factor, coupled with the data of agricultural land use type in Tianjin City and the ecological value equivalent table, the theoretical ecological value of agriculture in Tianjin City can be calculated[7].

If taking into account people's psychological endurance capacity and economic affordability, the theoretical value can not accurately reflect the actual ecological value of agriculture at different economic levels.

Therefore, we need to use the development stage coefficient representing the relative level of willingness to pay, to correct the theoretical ecological value of agriculture, thereby deriving the actual ecological value of agriculture. The development stage coefficient is calculated by Pearl growth curve and Engel coefficient, and the calculation formula is as follows:

$$l = \frac{1}{1 + e^{-t}} \qquad (2)$$

where is the society's willingness to pay for ecological and social benefits, $l \in (0, 1)$; $t = T - 3$, $T = 1/E_n$, $E_n$ is Engel coefficient; $e$ is the base number of natural logarithm.

Taking the development stage coefficient representing the willingness and ability to pay as the adjustment coefficient, we can correct the theoretical ecological value of agriculture, to derive the actual ecological value of agriculture. The calculation formula is as follows:

$$E_{areal}(t) = E_a(t) \times l(t) \qquad (3)$$

where $E_{areal}(t)$ is the actual ecological value of agriculture (yuan/$hm^2$).

On the basis of getting the real quantity of value of unit equivalent factor, we can calculate the actual ecological value of agriculture.

**2.2   The theoretical ecological value of agriculture in Tianjin City**   In 2010, the area of agricultural land in Tianjin City was 715 329 $hm^2$; the area of arable land was 443 704 $hm^2$; the area of garden plot was 31 228 $hm^2$; the area of forest land was 56 180 $hm^2$; the area of grassland was 610 $hm^2$; the area used for fishery production was 41 600 $hm^2$ [7].

The magnitude of value of agro-ecological unit equivalent factor in 2010 calculated based on formula (1) can be shown in Table 3.

**Table 3.    The magnitude of value of agro-ecological unit equivalent factor in 2010**

| Type of crop | Planting area 10³ hm² | Crop yield per unit area kg/hm² | Unit price of crop yuan/kg |
|---|---|---|---|
| Rice | 29 873 | 6 553. 11 | 2. 36 |
| Wheat | 24 257 | 4 748. 36 | 1. 98 |
| Corn | 32 500 | 5 453. 69 | 1. 97 |
| Soybean | 11 276 | 1 681. 89 | 3. 87 |
| Potato | 8 750 | 3 558. 97 | 5. 20 |

From Table 3, we derive the magnitude of value of agro-ecological unit equivalent factor in China in 2010 (11 950. 15 yuan/hm²).

Based on obtaining the magnitude of value of agro-ecological unit equivalent factor (Table 3), combined with the ecological value equivalent per unit area of agro-ecological system in China (Table 2), we can calculate the magnitude of ecological value of agricultural ecosystem in Tianjin City in 2010, and thus, according to agricultural productive land in Tianjin City, we can derive the theoretical ecological value of agriculture in Tianjin City in 2010. The specific calculation results are shown in Table 4.

**Table 4    The theoretical ecological value of agriculture in Tianjin City in 2010**                                    10⁸ yuan

| Ecological function | Arable land | Forest land | Grassland | Water area |
|---|---|---|---|---|
| Air regulation | 26. 512 | 36. 559 | 0. 058 | 0 |
| Climate regulation | 47. 191 | 28. 203 | 0. 066 | 2. 243 |
| Water conservation | 31. 814 | 33. 425 | 0. 058 | 99. 366 |
| Soil formation and protection | 77. 414 | 40. 737 | 0. 142 | 0. 049 |
| Waste disposal | 86. 958 | 13. 683 | 0. 095 | 88. 639 |
| Biodiversity conservation | 37. 647 | 34. 052 | 0. 079 | 12. 140 |
| Ecological entertainment | 0. 530 | 13. 370 | 0. 003 | 21. 160 |
| Total | 308. 066 | 200. 029 | 0. 501 | 223. 597 |

Based on Table 4, the total theoretical ecological value of agriculture in Tianjin City in 2010 is calculated at 73. 219 3 billion yuan.

## 2. 3    The actual ecological value of agriculture in Tianjin City

Due to economic development, living customs, ideologies and other factors, there are differences in the willingness to pay for different types of ecological functions between urban and rural residents; the willingness to pay for the ecological value also varies, and even there are significant differences.

The above factors will directly affect the ecological value of agriculture. Therefore, for the ecological value of agriculture, we can not only estimate the theoretical value, and there is a need to take into account the differences in people's actual willingness to pay.

In 2010, the urban Engel coefficient in Tianjin City was 35. 9%, rural Engel coefficient was 39%, and comprehensive Engel coefficient was 37. 45%. By the formula (2), we calculate the social development stage coefficient in Tianjin City in 2010 at 0. 42, as is shown in Table 5.

According to the above analysis, the actual value of unit

equivalent factor is 4 780. 06 yuan/hm² when considering the willingness to pay. By the formula (3), we calculate the actual ecological value of agriculture in Tianjin City in 2010 (Table 5). According to Table 5, the actual total ecological value of agriculture in Tianjin City in 2010 was 30. 752 billion yuan.

**Table 5    The actual ecological value of agriculture in Tianjin City in 2010**                                    10⁸ yuan

| Ecological function | Arable land | Forest land | Grassland | Water area |
|---|---|---|---|---|
| Air regulation | 11. 13 | 15. 35 | 0. 02 | 0. 00 |
| Climate regulation | 19. 82 | 11. 85 | 0. 03 | 0. 94 |
| Water conservation | 13. 36 | 14. 04 | 0. 02 | 41. 73 |
| Soil formation and protection | 32. 51 | 17. 11 | 0. 06 | 0. 02 |
| Waste disposal | 36. 52 | 5. 75 | 0. 04 | 37. 23 |
| Biodiversity conservation | 15. 81 | 14. 30 | 0. 03 | 5. 10 |
| Ecological entertainment | 0. 22 | 5. 62 | 0. 02 | 8. 89 |
| Total | 129. 37 | 84. 02 | 0. 22 | 93. 91 |

## 3    Analysis of contribution of ecological value of urban modern agriculture in Tianjin City

It is estimated that the total service value of agricultural ecosystem in Tianjin City in 2010 is 30. 752 billion yuan, basically tantamount to the total output value of agriculture in Tianjin City, but if the ecological value of agriculture is included in the agricultural value, total output value of agriculture will be doubled.

In terms of the ecological value per unit area, the ordering is as follows: water area > forest land > grassland > arable land. According to the total value of ecological services, the ordering is as follows: arable land > water area > forest land > grassland. The contribution rate of ecological value of arable land was the greatest, reaching 42. 07%, followed by water area, the ecological value of which accounts for 30. 54% of total ecological value. The contribution rate of ecological value of forest land is 27. 32%, and the contribution rate of ecological value of grassland is small, accounting for only 0. 07%.

The ecological value of different ecological assets is shown in Fig. 1. It can be seen that the ecological value of agriculture can not be ignored, which is especially important for the urban ecological environment construction in Tianjin City with a small proportion of ecological land[8].

There is difficulty in precise quantification of data and some parameters, and some factors are difficult to be exactly signified by data, such as the ecological aesthetic service value of agriculture. The ecological value of agriculture estimated here can not precisely reflect its total value. Nevertheless, the ecological value of urban modern agriculture in Tianjin City is very impressive, with good development potential[9]. Therefore, in the process of building urban modern agriculture in Tianjin City, there is a need to fully develop and tap the ecological service function of agriculture.

## 4    Countermeasures for the ecological function development of urban modern agriculture in Tianjin City

### 4. 1    Strictly protecting arable land and raising the standards of compensation for agricultural land requisition    Tianjin City
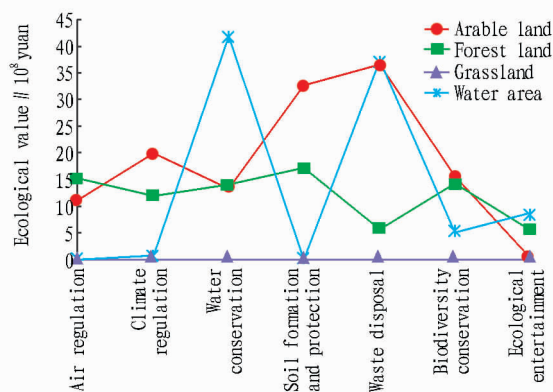
**Fig. 1   The ecological service value of different ecological assets**

is still in the stage of rapid urbanization and industrialization. With the continuous development of the city, a lot of surrounding farmland is occupied, and the pressure on the ecological environment is increased. Therefore, through the reform and innovation of land policy, it is necessary to improve and strengthen the land management operation mechanism, to curb the rapid decline in the growing area of crops. Moreover, it is necessary to take into account the ecological value of agriculture in the existing agricultural land requisition compensation standards, and raise the agricultural land requisition or expropriation compensation standards, to ensure the coordinated development of urban space, agricultural space and ecological space.

**4. 2   Actively and prudently developing facility agriculture and preventing the blind scale expansion of facility agriculture to better give play to its ecological function**   In recent years, Tianjin vigorously develops facility agriculture and has achieved remarkable results. But over-cultivation of facility agriculture will affect the play of ecological service function of agriculture. In terms of the current experience on the development of facility agriculture in the developed areas at home and abroad, the size of the facility agriculture does not simply mean the level of development of the region, but more reflects the sustainable use of resources, ecological environment protection, and public shared ecological benefits.

Therefore, in order to promote dramatic development of modern agriculture in Tianjin City, it is necessary to formulate incentive policy for agricultural construction, raise the level of industrialization, adopt technical measures, and improve service levels, to abate non-farm conversion of agricultural land, and effectively control the conversion rate of agricultural land[10].

**4. 3   Strengthening the construction of ecological agriculture and promoting the market conversion of the ecological service value of agriculture**   The share of the Chinese agricultural economic value in GDP constantly declines, and the pressure on ecological environment has become increasingly prominent. Agriculture has an irreplaceable function of ecological service, which is

one of important ways to promote rural economic development and increase farmers' incomes.

With the socio-economic development and improvement in the farmers' living standards, the ecological value of agriculture will gradually rise, and the development of agriculture ecological function is gradually integrated into the building of modern ecological agriculture[11].

**4. 4   Improving the environment to form relatively complete agro-ecological system**   Based on the current situation of ecological environment of agriculture in Tianjin City, we should adopt the following measures: (1) Continuing to strengthen afforestation, and increasing forest coverage; (2) Effectively protecting farmland, further improving farmland occupation compensation system, dynamic balance system of total farmland, and basic farmland protection system; (3) Building water-saving urban modern agriculture, and strengthening the management of water resources; (4) Controlling the township industrial pollution; (5) Through the control of pesticide use, prohibiting the highly toxic pesticides, and rationally using chemical fertilizer and agricultural plastic sheeting, to reduce soil and water pollution.

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