Agricultural Ecological Capital: Factor Structure, Value Assessment and Accumulation Mechanism

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Abstract As a kind of important new capital form, agricultural ecological capital plays a decisive role in guaranteeing healthy development of agricultural ecological economy. Therefore scientific understanding agricultural ecological capital is favorable for developing agricultural ecological economy, while clarifying factor structure, value assessment and accumulation mechanism of agricultural ecological capital is important content of understanding agricultural ecological capital. In this paper, factor structure of agricultural ecological capital is firstly elaborated, and it is thought that agricultural ecological capital is the unity of agricultural ecological environment, agricultural ecological resource and agricultural ecological system. Then agricultural ecological capital value is assessed according to use value method and non use value method, thereby realizing quantification of agricultural ecological capital. After agricultural ecological capital passes through value assessment, the value is more clear, which creates condition for agricultural ecological capital accumulation. Finally accumulation mechanism of agricultural ecological capital is analyzed. Accumulation channel of agricultural ecological capital is explored from natural and human factors, and it is found that agricultural ecological capital accumulates in the forms of agricultural ecological restoration and agricultural ecological compensation.

Key words Agricultural ecological capital; Factor; Value; Accumulation

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Agricultural ecological capital is all ecological factors input in agricultural industry, containing natural and human factors, namely the sum of agricultural ecological environment, agricultural ecological resource, service and function of agricultural ecological system. Of course, not all ecological capital is agricultural ecological capital, and it must be input in agriculture and is the capital formed by natural and human factors. Due to insufficient understanding on agricultural ecological capital in China for a long time and less research on factor, value and accumulation of agricultural ecological capital, it causes that agricultural ecological capital is very difficult to preserve or increase the value[1]. Therefore it is very necessary to enhance the research on agricultural ecological capital, especially the research on factor structure, value assessment, accumulation mechanism of agricultural ecological capital.

1 Factor structure of agricultural ecological capital

Agricultural ecological capital is a synthetic concept, containing the number and quality of agricultural ecological capital. Agricultural ecological capital exists in agricultural ecological system, and shows in the forms of agricultural ecological environment, agricultural ecological resource and whole service function of agricultural ecological system. Therefore agricultural ecological capital is a capital system composed of these factors in the content, and shows as the sum of various service flows provided by a whole which is composed of quality factor of agricultural ecological environment, quality and quantity of agricultural ecological resource, agricultural ecological system in the form (Table 1).

Quality factor of agricultural ecological environment is ecological environment quality factor system commonly constituted by quality, flow, transformation speed in various ecological environment quality factors and structure, combination among various ecological environment quality factors. This kind of agricultural ecological capital comprehensively shows as environmental capital, and its value mainly shows as existence value, and its function mainly shows as supporting life system. Specific category contains soil, climate, light, heat, water, gas, various nutrient substances, trace element, animal, plant and microorganism.

Quality and quantity of agricultural ecological resource contain quantity, quality of various agricultural ecological resources and their combination change. Structure, ratio, abundance, integration symbiosis and consumption competition relationship exist among various agricultural ecological resources, and this kind of agricultural ecological capital intuitively shows as resource capital. Its value mainly shows as use value, and its function mainly shows as supporting production system. Specific category contains land, water, climate, germplasm and biodiversity resources.

Whole service flow function of agricultural ecological system shows as habitat leisure, tourism, ecological experience education and ecological culture service. Various service flows form an integrated service flow singly or with other service

flows. This kind of service flow could provide high-end ecological consumption required by people, meet people's enjoy in the spiritual and ethical level, and improve the happiness degree and index of life. This kind of agricultural ecological capital is figuratively called as ecological service capital. Its value mainly shows as service value, and its function mainly shows as meeting people's spiritual and cultural needs. Specific category contains environmental self purification capacity, and providing leisure habitat, sightseeing appreciation, experience education, aesthetic ethics, ecological information transfer and ecological culture service.

Table 1 Stock component elements of agricultural ecological capital

No.	Category	Key attribute
1	Quality factors of agricultural ecological environment	
1.1	Water, surface and ground water	Category and quantity
1.2	Atmosphere, useful gas	Category and quantity
1.3	Organism, animal, plant and microorganism	Category and quantity
1.4	Soil	Category, area; soil layer thickness
2	Quantity and quality of agricultural ecological resource	
2.1	Water quality	Standard and grade
2.2	Air quality	Standard, grade and proportion
2.3	Biodiversity	Abundance
2.4	Soil fertility	Category
2.5	Climate	Life activity adaptability
2.6	Factor coordination situation	Comprehensive quality, structure and content
3	Whole service function of agricultural ecological system	
3.1	Gas absorption capacity	Greenhouse gas, toxic and harmful gases
3.2	Solid waste degradation ability	Biological plastids and other biodegradable substances
3.3	Liquid and waste purification capacity	Eutrophic water body
3.4	Life support service	Biosphere and mankind
3.5	Production support service	Production factor and environment
3.6	Life adjust service	Rest, sightseeing and leisure

2 Value assessment of agricultural ecological capital

Value assessment of agricultural ecological capital is the basis of conducting agricultural ecological capital operation. Only rationally assesses the value of agricultural ecological capital, could effective input and stable operation of agricultural ecological capital be guaranteed, and value preservation and increase of agricultural ecological capital could be promoted. Basic thinking of agricultural ecological capital value assessment is using the theory and method of environmental resource accounting, and referring to resource value assessment model to construct agricultural ecological capital assessment model, and then differential accounting of different types of agricultural ecological capital is conducted according to different agricultural ecological environmental conditions[2-3]. Due to diversification of agricultural ecological capital value, there are diverse agricultural ecological capital value assessment methods. In general, it could be divided into two kinds: use value assessment method and non use value assessment method. Specifically speaking, it contains marginal opportunity cost method, compensation value method, total economic value method, expected earnings capitalization method and alternative market value method.

2.1 Marginal opportunity cost method Marginal opportunity cost method is a kind of abstraction and measurement on development and utilization consequences of agricultural ecological capital from economics angle or economic activity consequence from sociological perspective. Its calculation formula is as below:

$$MOC = MPC + MUC + MEC \qquad (1)$$

where MOC is marginal opportunity cost; MPC is marginal production cost; MUC is marginal use (or depletion) cost; MEC is marginal external environmental cost.

2.2 Compensation value method According to labor value theory, ecological capital condensing abstract labor has the value. Seen from compensation angle, the value of agricultural ecological capital (W) contains three parts.

$$W = C + V + m \qquad (2)$$

where C, V and m respectively show materialized labor value, living labor value input in compensation and protection of one agricultural ecological capital and surplus value created by living labor. Compensation value method calculates two values of agricultural ecological capital by counting compensation expenditure of actual input, which considers historical cost attribute, with higher reliability. Meanwhile, the opinion that agricultural ecological capital not inputting human labor and inputting a small amount of labor also has the value has been gradually accepted. If the part of agricultural ecological capital is not counted, total value of ecological capital is extremely easy to be underestimated, thereby causing abuse and waste of agricultural ecological capital. Therefore, the method is mainly suitable for counting compensation value increase of agricultural ecological capital.

2.3 Total economic value method According to utility value theory, ecological capital value (TEV) is divided into two clas-

ses: use value(UV) and non use value(NUV), and UV is divided into direct use value (DUV), indirect use value (IUV) and option value (OV). Its calculation relationship could be shown as:

$$TEV = UV + NUV = (DUV + IUV + OV) + NUV \quad (3)$$

where DUV indicates the value of ecological resource and environment directly meeting people's some production and consumption demands, and it shows as material service function and could be counted by using market value method. IUV does not directly enter into people's production and consumption process, but could create necessary conditions for people's production and consumption. It shows as agricultural ecological system capacity and comfort function, and could be counted by using production function method, loss aversion method and precautionary expenditure method. OV is people's paid willingness of protecting current agricultural ecological resource environment to be used in the future, and is similar to insurance money that consumer is willing to pay one unused agricultural ecological resource environment. It shows as self sustaining function of agricultural ecological resource environment. NUV shows people's rational assessment on permanent share value of agricultural ecological resource environment and potential function value of ecological resource environment. DUV and IUV could be directly or indirectly counted by historical cost and current market price, with higher reliability. OV and NUV only could be counted by using value assessment method, with lower reliability and stronger subjectivity.

2.4 Expected earnings capitalization method According to land rent theory and financial management theory, expected earnings capitalization method takes the expected two values (expected rent or profit) generated by agricultural ecological resource environment in future certain time (such as 1 year) as ecological resource environment value according to present value after discount by social discount rate. Its calculation formula is as below:

$$V = V_1 + V_2 \quad (4)$$

$$V_1 = \frac{qR_0}{r} \quad (5)$$

$$V_2 = \frac{A(1 + K)}{nQ} \quad (6)$$

where V shows ecological resource environment value; V_1 and V_2 respectively show commodity and service values of agricultural ecological resource environment; R_0 shows basic land rent or basic rent; r is land rent rate or average interest rate; q is grade coefficient of agricultural ecological resource; A is total investment; Q is total beneficial resource amount; is beneficial time; K is capital profit rate. The method uses present value attribute of future cash flow, and could accurately reflect future economic benefit of agricultural ecological resource environment.

2.5 Alternative market value method Alternative market value method is using one kind of substitute with market price to indirectly measure the value of agricultural ecological goods without market value, mainly containing consequence prevention method and asset value method. Alternative market value assessment method of agricultural ecological capital is proposed to solve the contradiction between scarcity, finiteness of non renewable agricultural ecological capital and demand, consump-

tion of human society continuously increasing. The scarcity of any kind of non renewable agricultural ecological capital is relative, and it is because that people's demand on one agricultural ecological capital is its agricultural ecological capital feature but not matter itself. Matter characteristic of agricultural ecological capital is often replaced by matter feature of another resource.

3 Accumulation mechanism of agricultural ecological capital

3.1 Connotation of agricultural ecological capital accumulation The accumulation of agricultural ecological capital embodies increment, and increment of agricultural ecological capital is a kind of change status when compared with stock. The aim of agricultural ecological capital accumulation is realizing value preservation and increase of ecological capital. So it must maintain non-reduction of agricultural ecological capital stock firstly, thereby realizing value increase of agricultural ecological capital via agricultural ecological capital operation[4]. Value increase of agricultural ecological capital contains quality improvement and quantity increase. Quality improvement is realized by whole improvement of ecological environment quality, while quantity increase is completed by accumulation of agricultural ecological capital. Direct result of agricultural ecological capital accumulation is forming increment of agricultural ecological capital. In operation process of agricultural ecological capital with benign circle, stock of agricultural ecological capital changes due to increment, and increment of agricultural ecological capital is from agricultural ecological capital stock activated by derivative effect of ecological construction investment.

Formation manner of agricultural ecological capital increment is agricultural ecological capital accumulation, and agricultural ecological capital accumulation contains two kinds of manners: natural and human accumulation. Natural accumulation is natural regeneration and growth of ecological capital, self replacement and adjustment of ecological system in its collaborative evolution process, and is acted by natural rule and restricted by integrity of ecological system. Agricultural ecological capital has systematicness, integrity and threshold, and increasing velocity of its natural accumulation is generally a constant. Human accumulation of agricultural ecological capital indicates a kind of accumulation process that people purposefully and consciously form ecological capital via ecological investment, that is to say, material, human and social capital is transformed into ecological capital. This is accumulation formed by the transformation among various capital forms, and its essence is mutual transformation between natural part and human part in agricultural ecological capital. Natural part contains natural regeneration and growth, while human part contains ecological promotion and destruction. Comprehensive effect of these factors forms final accumulation of agricultural ecological capital (Fig.1).

Same as other capital, agricultural ecological capital movement also contains two manners: accumulation and consumption. The consumption of agricultural ecological capital shows as the development and use of ecological resource and ecological environment, and is also a kind of movement manner of to-
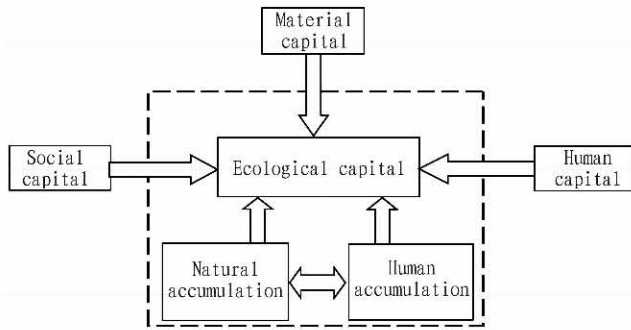
Fig.1 Ecological capital accumulation

tal ecological capital gradually decreasing. If using V_c, V_n and V_h to respectively represent consumption of agricultural ecological capital, natural accumulation of agricultural ecological capital and human accumulation of agricultural ecological capital, above dissertation could be described as:

(1) At initial development stage of human society, the consumption of agricultural ecological capital is lower than its natural reproduction ability, $V_n > V_c$.

(2) Since enters into industry society, large-scale economic and social practice is started, and productivity level is greatly improved, and the consumption of ecological capital continuously increases. Meanwhile, the consumption of ecological capital destroys natural reproduction ability of ecological system in the manners of deforestation and sewage discharge. It causes that natural accumulation of agricultural ecological capital is seriously insufficient and is far lower than consumption increase rate of ecological capital at the same stage, and $V_c > V_n$.

(3) After enters into sustainable development stage, people understand that it must radically change traditional relationship between accumulation and consumption of agricultural ecological capital. On the one hand, it should decline consumption velocity of agricultural ecological capital. On the other hand, it should improve human accumulation level of agricultural ecological capital to make its accumulation higher than consumption growth level, thereby realizing sustainable use of agricultural ecological capital and sustainable development of economic society, namely $V_h + V_n > V_c$. V_n indicates that ecological capital could maintain increase trend and sustained proliferation capacity, and promote continuous increase of V_n by depending on human, material and financial resources input in each area. When V_n restores, it could reach the balance between ecological system and economic system.

Besides general provisions of ecological capital accumulation and consumption, accumulation and consumption of agricultural ecological capital also should follow special ecological rule of agricultural ecological system. Agricultural ecological system is an artificial ecosystem established on natural ecological system and is restricted by natural environment to a great extent. Only creating good agricultural ecological environment via agricultural ecological capital accumulation, could better economic benefit be obtained. Good agricultural ecological environment depends on the support, protection and adjustment of agricultural ecological system, such as forest, grassland and waters, but agricultural ecological system has simpler structure than natural ecological system, with less biological species, short food chain and weaker self regulating ability, and it is easy to be affected by natural climate, plant diseases and insect pests, weed growth. Therefore, it needs continuously adjusting and optimizing the structure and function of agricultural ecological capital via human ecological construction and management, which could obtain the maximum output of agricultural production and good economic benefit.

3.2 Accumulation channel of agricultural ecological capital According to the manner and requirement of agricultural ecological capital accumulation, channel of agricultural ecological capital accumulation mainly contains agricultural ecological restoration and agricultural ecological compensation[5]. Agricultural ecological restoration is effective measure and way of promoting natural accumulation of agricultural ecological capital, and agricultural ecological compensation is basic method and necessary way for human accumulation of agricultural ecological capital.

Agricultural ecological restoration is realized by self organizing feedback mechanism of agricultural ecological system. Under external interference situation of not exceeding ecological threshold value, agricultural ecological system could maintain relative stable status of its structure and function within certain time, or restore to original status in very short time after deviating ecological balance. But if exceeding self regulation range of agricultural ecological system, the impaired agricultural ecological system could not naturally restore to its initial stable status. At this time, it needs conducting human adjustment and restoration of agricultural ecological system, or else ecological system will be in impaired status for a long time, which could not conduct natural accumulation of agricultural ecological capital.

Agricultural ecological compensation is an important means for human accumulation of agricultural ecological capital. The investment of agricultural ecological system by agricultural ecological compensation could effectively compensate mass energy output of agricultural ecological environment and consumption of agricultural ecological resource[6], thereby maintaining non reduction of agricultural ecological capital stock. Moreover, agricultural ecological construction via material and technical inputs of agricultural ecological compensation could improve the quality of agricultural ecological environment, thereby realizing long-term whole value increase of agricultural ecological capital.

3.2.1 Agricultural ecological restoration. When valuing the protection of agricultural ecological system, agricultural ecological restoration repairs the impaired agricultural ecological system and creates good external ecological environment for the development of ecological agriculture. The targets of agricultural ecological restoration mainly contain: ① restoring original rational community structure and species collection of agricultural ecological system. ② Agricultural ecological system is composed of local species at the most feasible level. Weed species is usually settled in disturbed areas, and they often grow mixedly with crop. The restored plantation system, exotic domestic animals and non invasive plants in weed should be allowed to exist, and it is because that they could conduct coevolution with local species. ③ Physical environment of agricultural ecological system could provide basic conditions for maintaining population

reproduction, stability and development, thereby conducive to system further restoring to historical state. ④ The function of agricultural ecological system could be played normally, and the signal of dysfunction could not appear in each historical period. ⑤ Agricultural ecological system and its surrounding environment could integrate into a large ecological site or landscape via flow and exchange of non-organism and organism. ⑥ Potential threat threatening the health and integrity of agricultural ecological system in surrounding landscape has disappeared or has been declined to the maximum possible. ⑦ Agricultural ecological system has sufficient restoring force, and could endure normal periodic fluctuation stress in local environment, thereby maintaining its integrity.

The type of agricultural ecological restoration contains forest ecological restoration, waters ecological restoration, grassland ecological restoration, ocean and seacoast ecological restoration, wasteland ecological restoration. Main techniques of agricultural ecological restoration contain biological restoration technique, plant restoration technique, physical restoration technique and chemical restoration technique. Biological restoration technique contains in situ bioremediation, ex situ bioremediation, in situ and ex situ combined remediation. Phytoremediation technology mainly embodies in plant restoration caused by heavy metals and organic pollutants. Physical restoration techniques mainly contain physical separation and repair technology, steam extraction and recovery technology, solidification repair technology, vitrification repair technology, thermodynamic remediation technology, thermal desorption repair technology, freeze repair technique and isolation embedding technology. Chemical remediation techniques contain chemical leaching repair technology, solvent extraction repair technology and chemical oxidation repair technology.

3.2.2 Agricultural ecological compensation. Agricultural ecological compensation is a kind of system arrangement of paying compensation fee on agricultural ecological product and ecological service. By paying direct cost and opportunity cost of ecological protection, ecological restoration and ecological development to agricultural operator[7], it impels people changing traditional agricultural production manner of high consumption and pollution, and using green agricultural production manner, to reach the aim of protecting and improving ecological environment, enhancing ecological service function, improving agricultural comprehensive benefit, finally realizing harmonious unification of agricultural economic benefit, social benefit and ecological benefit.

Realization form of agricultural ecological compensation is compensation subject paying capital or object to compensation object[8]. It contains compensation subject, compensation object, compensation range, compensation manner, compensation channel and compensation standard, in which the determination of compensation standard is the key point and difficulty. In the practice, the determination of agricultural ecological compensation standard could refer to the cost of ecological protector[9], the cost of ecological restorer, profit of ecological beneficiary, and value of ecological system service.

(1) Calculation according to the cost of ecological protector. The region or group engaged in agricultural ecological capital operation belongs to ecological protector, and manpower, material and financial resources input in agricultural ecological capital operation process by ecological protector should be contained in direct cost. Meanwhile, the development right directly or indirectly sacrificed by agricultural ecological capital operation should be taken as opportunity cost, which is included in the scope of agricultural ecological compensation. Said from the theory, the sum of direct input cost, indirect input cost and opportunity cost should be the minimum standard of agricultural ecological compensation[10]. Cost calculation formula of ecological protector should be as below:

$$\sum C = (1 + i)^{T-t+1} \sum_{t=1}^{T} C_t \qquad (7)$$

where C is total cost after discount; C_t shows total investment cost in the tth year; T is cumulative year number of continuous input; i is social discount rate.

(2) Calculation according to the cost of ecological restorer. Agricultural ecological capital operation needs treating the polluted agricultural ecological environment and restoring the impaired agricultural ecological resource. This part of treatment and restoration cost should be taken as important component of agricultural ecological compensation to impel agricultural producer transforming traditional agricultural production manner and selecting agricultural ecological capital operation manner. In the practice, below formula could be used to count the cost of ecological restorer:

$$G = \sum_{i=1}^{n} k \cdot P_i + C_o \qquad (8)$$

where G is the restoration cost of the impaired agricultural ecological resource; i is the directly or indirectly impaired various ecological environmental factors, such as land, water, air and landscape; k shows correction factor according to different geographical positions, resource conditions and development manners; P_i is the value of the ith impaired ecological environmental factor; C_o is the lost development opportunity cost.

(3) Calculation according to the profit of ecological beneficiary. Ecological beneficiary does not pay the enjoyed ecological products and service, which causes that the contribution of agricultural ecological capital operator does not receive the due reward, thereby generating positive externality of agricultural ecological capital operation. To make externality of agricultural ecological capital operation internalization, it inevitably needs ecological beneficiary paying corresponding fee to agricultural ecological capital operator. The profit of ecological beneficiary could be determined by market transaction price P and trading volume Q of ecological agricultural product. Specific calculation formula is as below:

$$\sum C_t = \sum_{i=1}^{n} V_i \cdot (P_i \cdot Q_i + C_i) \ (C_i = \max\{U_1, U_2, U_3, \cdots, U_5\}) \qquad (9)$$

where C_t is total fee of ecological compensation paid by beneficiary; P_i shows market price of the ith kind of ecological agricultural product; Q_i is the purchase amount of the ith kind of ecological agricultural product; C_i is the opportunity cost of buying the ith kind of ecological agricultural product; $U_1, U_2, U_3, \cdots, U_5$ are the purchase benefits of other agricultural products; V_i shows the ecological compensation payment proportion of the ith

products[J]. Scientia Meteorologica Sinica, 2008, 28(6): 689 – 696. (in Chinese).

[17] WILSON JW, REUM D. "The hail spike": Reflectivity and velocity signature//23d Conf. on Radar Meteorology. Snowmass, CO: Amer Meteor Soc. 1986: 62 – 65.

[18] WILSON JW, REUM D. The flare echo: Reflectivity and velocity signature[J]. Journal of Atmospheric & Oceanic Technology, 1988,5(2):197 – 205.

[19] ZRNIC DS. Three-body scattering produces precipitation signature of special diagnostic value[J]. Radio Science, 1987,22(1): 76 – 86.

[20] LEMON LR. The radar "three-body scatter spike": An operational large-hail signature[J]. Weather & Forecasting, 1998,13(2): 327 – 340.

[21] ZHU MH, YU XD, XIA F, et al. Analysis on strong hail storm three-body scattering signature using Doppler weather radar data [J]. Quarterly Journal of Applied Meteorology, 2006,17(20): 215 – 223. (in Chinese).

[22] LIAO YF, YU XD, WU LL, et al. Statistic and case studies on radar three body scattering of severe hailstorm[J]. Plateau Meteorology, 2007,26(4):812 – 820. (in Chinese).

[23] PAN YJ, ZHAO K, PAN YN. Single doppler radar observation of a heavy precipitation supercell on a severe squall line[J]. Acta Meteorologica Sinica, 2008,66(4):621 – 636. (in Chinese).

[24] ZHANG YI, YUAN Y, ZHANG P, et al. A comparison analysis of formation conditions between the hailstorms occurred in winter and spring[J]. Scientia Meteorologica Sinica, 2004, 24(3):357 – 360. (in Chinese).

[25] CAO GF, ZHANG SJ, ZHU GZ, et al. Weather analysis and forecasting in Shandong [M]. Beijing: Meteorological Press, 1988: 124 – 128. (in Chinese).

[26] WANG TT, WANG YC, CHEN MX, et al. The contrastive analysis of formation of dry and moist thunderstorms in Beijing[J]. Meteorological Monthly, 2011,37(2):142 – 155. (in Chinese).

[27] LU HC. Principle and forecast of mesoscale weather[M]. Beijing: Meteorological Press, 2004:258 – 259. (in Chinese).

[28] ZHU QG, LIN JR, SHOU SW, et al. Principle and method of synoptic meteorology[M]. Beijing: Meteorological Press, 2007: 412 – 422. (in Chinese).

kind of ecological agricultural product.

(4)Calculation according to value of agricultural ecological system service function. In agricultural ecological compensation, the calculation of agricultural ecological system service value indicates comprehensive assessment and accounting on agricultural ecological system service provided by agricultural producer. Accounting methods mainly contain market value method, shadow price method, shadow project method, fee analysis method, human capital method, assets value method and condition value method, in which market value method is the simplest and common method, and its calculation formula is as below:

$$V = \Delta Q \left(\frac{P_1 + P_2}{2} - C_v \right) - C \qquad (10)$$

where V shows the value of agricultural ecological system service; ΔQ is change amount of ecological agricultural product yield; P_1 shows per unit ecological agricultural product price before yield change; P_2 is per unit ecological agricultural product price after yield change; C_v is per unit variable cost of ecological agricultural product; C is total production cost.

References

[1] JAMES A, SUZANNE J, MILTON, et al. Restoring natural capital: Science, business and practice[M]. Washington: Island Press, 2007.

[2] PETER K, HEATHER T, TAYLOR H, et al. Natural capital: Theory & practice of mapping ecosystem services[M]. New York: Oxford University Press, 2011.

[3] ROLDAN M, CARDENAS J. From market failures to collective action dilemmas: Reframing environmental governance challenges in Latin America and Beyond[J]. Ecological Economics, 2015, 120(10): 1 – 8.

[4] FRANCISCO A, COMIN. Ecological restoration: A global challenge[M]. New York: Cambridge University Press, 2010.

[5] HERMAN E, DALY, JOSHUA F. Ecological economics: Principles and applications [M]. Washington: Island Press, 2004.

[6] HOWARD K, ADAM R. The economics of natural hazards Cheltenham[M]. Edward Elgar Press, 2004.

[7] KAUS D, SONG Q. The potential of land rental markets in the process of economic development: Evidence from China [J]. Journal of Development Economic, 2005(3): 125 – 129.

[8] BARBIER, EDWARD B. Capitalizing on nature[M]. New York: Cambridge University Press, 2011.

[9] NIELS J, MICHAEL T, URSULA W, et al. How can we identify and communicate the ecological value of deep-sea ecosystem services? [J]. Plosne, 2014, 9(7): 1 – 10.

[10] FENCH A, FOSTE R, HAMILTON K, et al. Natural capital in ecology and economics: An overview[J]. Environmental Monitoring and Assessment, 2003, 86(1): 3 – 17.