Environmental Technology & Innovation 22 (2021) 101390

Contents lists available at ScienceDirect

Environmental Technology & Innovation

journal homepage: www.elsevier.com/locate/eti

Agricultural and rural ecological management system based on big data in complex system

Fazheng Chen [a,b], Yuanhong Hu [c,*]

[a] College of History and Ethnic Culture, Guizhou University, Guiyang 550025, Guizhou, China
[b] Anshun Experimental Zone Development Research Center, Anshun University, Anshun 561000, Guizhou, China
[c] College of Business, Shanghai University of Finance and Economics, Shanghai 200433, China

ARTICLE INFO

Article history:
Received 26 November 2020
Received in revised form 18 January 2021
Accepted 23 January 2021
Available online 6 February 2021

Keywords:
Complex system
Big data
Agricultural ecosystem
Ecological management system

ABSTRACT

The rural agricultural ecosystem has an important influence on the development of our country's economy, society and ecological environment at any time. In recent years, our country has paid more and more attention to rural agriculture, and scientific and reasonable management of the agricultural ecosystem is a problem that everyone is more concerned about. In order to solve the management problem of rural agro-ecosystem, this article uses big data as the research background and constructs an ecological management system index system for rural agro-ecosystem based on complex system theory. The experiment uses fertilizer consumption, water pollution degree, pest degree, carbon and nitrogen absorption and agricultural economic benefits in a rural agricultural ecosystem in a certain area as the system indicators of the ecological management system. Use data mining technology in big data to collect and process relevant data in the network, analyze and understand the agricultural ecosystem through complex systems, and finally calculate and analyze the data of various indicators. The final result showed that the consumption of fertilizer in the rural area with the introduction of the agricultural ecological management system was 70 kg/m^2 less than that in another rural area, and the water pollution and insect pests were two degrees lower than the other rural area. From 2019 to 2020, due to the introduction of the agricultural ecological management system, the carbon absorption of the agricultural ecosystem increased to 166 mt and 241 mt, and the nitrogen absorption increased to 1134 mt and 1430 mt. And under the influence of the agricultural ecological management system in this area, the total agricultural economic income of rural D and rural E that introduced the system was 12.51 million, which was 1.98 million more than the other three rural areas. It can be seen that the agricultural ecological management system has a positive effect on the rural agricultural ecological system.

1. Introduction

1.1. Background meaning

In recent years, the country's strong support for rural agriculture has made the development of rural agriculture better and better. However, with the development of rural agriculture, the demand for energy consumption and related resources

* Corresponding author.
E-mail addresses: aschenfazheng123@163.com (F. Chen), hover_hyh@yeah.net (Y. Hu).

https://doi.org/10.1016/j.eti.2021.101390
2352-1864/© 2021 Published by Elsevier B.V.

in agriculture is increasing. At the same time, the irrational control of the rural agricultural ecosystem has caused serious pollution in the countryside and its surrounding environment, and the greenhouse effect and environmental pollution have become increasingly serious. Therefore, it is one of the imperative tasks to implement reasonable and effective scientific management of my country's agricultural and rural ecosystems. In order to solve the management problems of rural agro-ecosystems, many scholars have studied many initiatives and practices in rural agricultural ecosystems and agro-ecosystems were effectively managed. However, these management measures and methods have relatively little effect on the management of rural agricultural ecosystems. Therefore, based on the reference of scholars' relevant research, this experiment constructed an indicator system of agro-ecological management system to manage the rural agro-ecological system, and conducted related research on the system.

The research on agricultural and rural ecological management system is helpful for rural farmers to plan and manage agriculture reasonably, improve the environment of rural ecosystem, reduce the pollution brought by agricultural ecosystem, and study the agricultural ecological management system can promote the development of rural agricultural economy and improve the living standard of rural farmers. The research on agricultural ecological management system has important practical significance and scientific research value.

1.2. Related work

At present, many scholars have carried out relevant research on agricultural ecological management system. Xie proposed an inaccurate random fuzzy programming model for irrigation water resource allocation and land resource utilization management. Xie's model directly integrates uncertainty into the optimization process by reflecting parameters and coefficients as interval values, fuzzy sets, random variables and their combinations (Xie et al., 2017). The purpose of Lammoglia is to evaluate the leaching of pesticides in crop systems that combine the performance of the crop model (STICS) and the pesticide fate model (MACRO). The results show that the performance of STICS-MACRO is similar to or better than that of MACRO. The improvement of crop growth simulation makes it possible better estimate crop transpiration, it is possible to better estimate the water balance (Lammoglia et al., 2017). He designed a modern agro-ecological park intelligent management system based on the Internet of Things, including adaptive agronomy technology, pest prevention and control technology, park geographic information management system and QR code traceability system to monitor crop growth in the park by region management, and develop the appropriate phone APP for park managers and visitors to use, intelligent eco-tourism model (He and Huang, 2019). However, these studies still have some shortcomings. Xie's research process is complicated, data calculation is too difficult, Lammoglia's research data is too little, the research results are too one-sided, and He's research cost is too high to apply to all experiments.

1.3. Innovation in this article

This paper uses big data mining technology to collect and process rural agriculture-related data in the big data environment, and uses complex system theory to analyze and understand agricultural ecosystems. Refer to previous scholars' related research to study and analyze agricultural ecological management systems. The impact of agricultural ecological management system on rural agricultural ecological system.

2. Related technologies of agricultural and rural ecological management system

2.1. Complex system

Complex system is a very important research object in the subject of complexity, and it is everywhere in our daily life (Lopez-de Ipina et al., 2020; Santos and Renato, 2017). In different disciplines and different fields, the definition of complex system is also very different, which is also a manifestation of the complexity of complex system itself. In systems science, a complex system has a large number of intersecting parts, and the relationship between individuals within the system is very complex, and presents a non-linear state, and analyze the part of the system to understand the whole system (Chen et al., 2016). In terms of formalization, a complex system cannot be calculated, it cannot be accurately described using a rule system, and can only be described approximately through various simulation experiments. The complex system communicates with the outside world and other subjects through its adaptability, so as to continuously learn and evolve itself. The complex system has uncertainty due to its non-computational characteristics. We cannot restore the history of the system, nor can we predict the future of its evolution (Sheila, 2016; Danzer et al., 2016). The emergence of a complex system makes the system as a whole present unique characteristics that are different from any individual and part within it, and the system emerges hierarchically, so that the micro and macro parts of the system form an inseparable organic whole. Although the whole complex system is unique and emerges at multiple levels, there are connections among the various subjects in the system, they interact and flow with each other, and finally form an organic whole (Yu et al., 2016). In the research of complex systems, complex networks are an essential part. A complex network is a mathematical model in a complex system. Its purpose is to analyze the network phenomenon and its complexity in the system.

There are already some mature methods and technologies for modeling complex systems, and agent technology has played a very important role in this aspect. The basic modeling methods of complex systems include deduction-inductive modeling and decomposition-joint modeling. Next, some common modeling methods of complex systems will be introduced.

Qualitative modeling based on quantity space: A quantity space is obtained by dividing the variable state space, and the division operation is expressed in the mapping form of formula (1):

$$f_y : T^n \to \widetilde{W}_d \tag{1}$$

$\widetilde{W}_d$ is an independent finite set, if the variable is represented as $\{+, 0, -\}$, which means that the variable will be divided into $[\infty, 0), 0, (0, \infty]$ three quantity spaces.

Block-integrated modeling method: This method can be used to model systems with complex structures and external environments. This method mainly divides the system into several subsystems according to the function of the system, and then establishes its associated model. The simulation description of this modeling method can be expressed as:

$$F = [S, I_F, O_F, N\{P_n|n \in N\}\{E_n|n \in N \cup (N)\}\{F_n'|n \in N \cup (N)\}] \tag{2}$$

S is a set of finite changes, I_F is external input, Q_F represents external output, N represents the collection of all internal subsystems, P_n is the input and output system of all subsystems, E_n represents the set of subsystems that affect n, F_n' is the interface mapping of n. For P_n:

$$P_n = [S, I_n, O_n, U, Q, H, G] \tag{3}$$

Q is the state collection of the system, G is the output expression of the system, U is the input set that allows segmentation, H is the system global state transition function.

Hybrid modeling method: The hybrid modeling method is to mix two or more methods together, complement and coordinate each other, and finally achieve unified modeling. The analysis-statistics method in the hybrid modeling method has a higher accuracy in modeling. The amount of information required in mathematical modeling will reduce $(1 - \hat{p}) \times 100\%$.

$$\hat{p} = \sum_{i=0}^{n} \hat{p}_i \tag{4}$$

$\hat{p}_i$ is used to replace the estimated value of the unknown parameter p_i of the parameter x_i. Through this method, the distribution p of some characteristic vectors x of the system can be analyzed:

$$p_i = p\{x = x_i\} \tag{5}$$

The modeling efficiency K_x of this method can be expressed as:

$$K_a = \frac{d_c}{d} = \frac{[\sum_{i=0}^{n} \hat{p}_i \sqrt{x_i'(1 - x_i')}]^2}{(Z/\sum_{i=0}^{n} \hat{p}_i)(1 - Z/\sum_{i=0}^{n} \hat{p}_i)} \tag{6}$$

d_c is the number of iterations of model identification in the single system identification method, d is the number of iterations of model identification in the single system identification method, Z is the system effectiveness index, x_i' is the conditional validity index of the system vector under certain conditions.

Agent as a very important modeling technology in complex systems, can continuously perceive changes in the outside world and its own state of the system, and make corresponding actions autonomously. The system structure of agent refers to the information and control relationship between the agents in the system. The system structure of agent is divided into three categories. The agent of the reactive structure only reacts to the current environment without considering the historical state and environmental factors of the system. Its mathematical model can be defined as

$$Ag : E \to A_c \tag{7}$$

The reactive structure agent expresses the agent's perception ability through the perception function *see*, and expresses the agent's action execution process through the action function *action*. The model expressions of the two functions are as follows:

$$see : E \to per \tag{8}$$

$$action : per \to A_c \tag{9}$$

per stands for perception set, the perception function maps the state in the environment to the agent's perception sequence, and the action function maps the perception sequence to the action.

Cognitively structured agents have the ability to logically reason about the environment and behavior, and display the reasoning results in the form of symbolic models. In addition to the perception function and action function, the cognitive agent also includes a function *next*, so the cognitive agent can be represented by a triplet:

$$\text{Agent} = \langle see, next, action \rangle \tag{10}$$

The three functions of cognitive agent can be expressed by the following formulas:

$$see: E \to per \tag{11}$$

$$next: D \times per \to D \tag{12}$$

$$action: D \to A_c \tag{13}$$

D is the database in the system, and its internal elements are theorem formulas, *next* function maps the database and perception sequence to the new database.

The agent of the hybrid structure combines the characteristics and advantages of the reactive and cognitive structures, and contains at least two or more subsystems. Hybrid agent is hierarchical and prioritized, in which the reactive subsystem takes precedence over the cognitive subsystem.

2.2. Big data

Big data usually refers to a very large data collection or data information, which cannot be defined and described in accurate language (Zhou et al., 2017). Due to its huge and complex data structure, big data has been unable to collect, search, share and analyze data within a certain period of time with traditional tools and methods. Someone analyzed the four characteristics of big data, volume, velocity, variety and value (Dubey et al., 2016). The large scale of big data requires an equal amount of storage space for data storage when applying big data. If the data is to be processed, the amount of calculation will also be very complicated (Agrawal and Choudhary, 2016; Whyte et al., 2016). Before big data came out, traditional data needed to build models when dealing with and solving problems, and to make logical inferences to the problems to get the final result. The emergence of big data has changed this complex step. When the amount of data in the question is sufficient, even without accurate algorithms and models, a conclusion close to the correct answer can eventually be obtained (Wu et al., 2016). Moreover, with the continuous advancement of technology, big data has lower and lower requirements for data structure, and a complete and reliable conclusion can be obtained by fusing data with different structures.

In the era of big data, people are getting more and more sophisticated in data mining and analysis and processing capabilities, and many technologies and methods have been innovated as a result. Many enterprise applications during large data mining and analysis to a number of related mining tools and techniques, such as artificial intelligence, machine learning, statistical theory (Kune et al., 2016). The basic methods of big data mining and analysis include classification, clustering, regression and correlation. In data mining, the classification method is to compare the differences between the categories in the known characteristics of certain categories, or compare the characteristics of the categories according to a standard, and then classify things with the same characteristics into a category. The principle is to give a database D with unknown data characteristics and a class D' with known characteristics, and then map these two classes:

$$D = \{d_1, d_2, \ldots, d_n\} \tag{14}$$

$$D' = \{d'_1, d'_2, \ldots, d'_m\} \tag{15}$$

$$f: D \to D' \tag{16}$$

Make each element in D be assigned to a class. One of the classes D'_j contains all the elements mapped to this class:

$$D'_j = \{d_i | f(d_i) = D'_j,\ 1 \le i \le n,\ d_i \in D\} \tag{17}$$

The clustering method is to divide the data into different classes by using iterative methods. There is a high difference between classes and other classes, but the elements within the class are highly clustered. Assuming that a_i is used to represent the elements in the data set, and b_j is the mean value of class B_j, the objective function of similarity within classes can be expressed as:

$$F = \min \sum_{j=1}^{k} \sum_{a_i \in B_j} (x_i - b_j)^2 \tag{18}$$

Regression method is one of the more common methods of mathematical statistics. It uses regression equation to study the relationship between variables. Regression analysis methods include linear regression and multiple linear regression, etc. The formula expressions are as shown in formulas (16) (17), and α, β is the regression coefficient:

$$y = \alpha + \beta_1 x \tag{19}$$

$$y = \alpha + \beta_1 x + \beta_{2x} \tag{20}$$

$$\alpha = \overline{y} - \beta \overline{x} \tag{21}$$

$$\beta = \frac{\sum_{i=1}^{S} (x_i - \overline{x})(y_i - \overline{y})}{\sum_{i=1}^{S} (x_i - \overline{x})^2} \tag{22}$$

Association method is a method used to discover some hidden association relations, patterns or rules between things.

2.3. Agricultural ecosystem

Agricultural ecosystem refers to an ecosystem composed of agricultural biological populations and agricultural ecological environment. The agricultural ecosystem is the product of human's long-term role in agricultural production and life, and it is the survivor who has been preserved after the test of time and history accumulation (Zhenmian et al., 2016). When the construction of agro-ecosystems, people rarely help to improve the external environment, agro-ecosystems, ecosystem health to make agriculture continues, only self-maintenance of the system, the system changes with the progress of the natural world and become more perfect. In order to satisfy people's survival and development, it is necessary to adjust the structure and function of the agricultural ecosystem and ensure the stability of the system (Jun and Hui, 2019). The agricultural ecosystem reflects the cultural, political and economic level related to agriculture in a certain period of development in history, and has witnessed the far-reaching influence of agricultural activities on the historical development period and the development status of that period (Zhang et al., 2018). The agricultural ecosystem is based on the biodiversity of the natural world, and for the survival and development of mankind, an ecological diversity system in which man and nature interact and coexist harmoniously has been formed. The biodiversity of the agricultural ecosystem plays an important role in the development of regional agriculture, the research of future biotechnology, and the cultivation of new varieties (Deng et al., 2020; Pérez-Gutiérrez et al., 2017). The agricultural ecosystem has a certain degree of stability, it can have strong anti-interference ability under the influence of various comprehensive factors, and it can also recover itself after being disturbed (Mehra et al., 2020; Xu et al., 2020).

2.4. Ecological management system

Ecological management is a marginal interdisciplinary subject in an interdisciplinary field, which involves relevant knowledge in the fields of ecology, biology, economics, environmental science (Hossain et al., 2020; Ray et al., 2016). Ecological management uses a variety of interdisciplinary theories and modern science and technology to manage organisms in the ecological environment, trying to balance the development of the ecological environment and the relationship between man and nature, and realize the coordinated and sustainable development of modern economy, society and the ecological environment (Ciftcioglu, 2017; Blanco et al., 2017). Ecological management system is a complex system engineering, composed of multiple organic management element subsystems with internal linkage mechanism (Guan et al., 2019). The operating framework of the ecological management system reflects the sustainability of the development of rural agricultural ecosystems and the environment and economy. The agricultural ecological management system mainly includes the target subsystem, the power subsystem, the support subsystem, the coordination subsystem, and the supervision and guarantee subsystem. Subsystem goal is to maximize the benefits for the purpose of agricultural production, without affecting the agricultural ecological environment, the sustainable development of agriculture in rural areas, which have in an integrated and sustainable of the ecological, economic and social benefits specific expression. The power subsystem is to promote rural agriculture through the government's release of relevant policies, and then conduct market transactions for products in rural agriculture to realize the circulation of items in the agricultural ecosystem. Finally, relevant personnel participate in the construction of the agricultural ecosystem together, and the implementation of the system management tools. The support subsystem is an important part of the rural agricultural ecosystem, including technical support for agriculture, infrastructure support and policy support. The coordination subsystem is an indispensable part of the rural agricultural ecosystem. It ensures the stability of the agricultural ecosystem by coordinating the internal and external aspects of the agricultural ecosystem. The supervision subsystem guarantees the benign operation of the agricultural ecosystem by restricting the related activities in the agricultural ecosystem. It can be used to supervise and evaluate all activities in the agricultural ecosystem.

3. Experimental design of agricultural and rural ecological management system

3.1. Data collection

The experiment takes big data as the research background and uses data mining methods to collect experimental data in the network environment. This article first refers to the research results of other scholars related to the agricultural ecological management system in the past five years, then uses the Internet to search for information related to this experiment in the big data, and finally according to the news reports and related websites of rural agriculture in various regions information this experiment summarized in data acquisition operations.

3.2. Relevant index system for ecological management system research

At present, the research system of domestic ecological management system is mainly based on the perspective of systematics, and the research area is divided into three modules of ecology, economy and environment for analysis. This experiment constructs an index system for an ecological management system, studies the rural agricultural ecosystem in a certain area, and analyzes the specific conditions of the rural agricultural economy, environment and ecology in the area. In this experiment, the indicators of the agricultural ecosystem system are set as fertilizer consumption, water pollution

Table 1
Statistics of fertilizer consumption, water pollution and pests.

	Unused			Use		
	Fertilizer	Water pollution	Pests	Fertilizer	Water pollution	Pests
2016	561	7.5	7	417	5	6
2017	527	7	8	383	4.5	5
2018	431	5	10	310	3	5.5
2019	618	9	8	512	6	7
2020	433	6	6.5	363	4	4.5

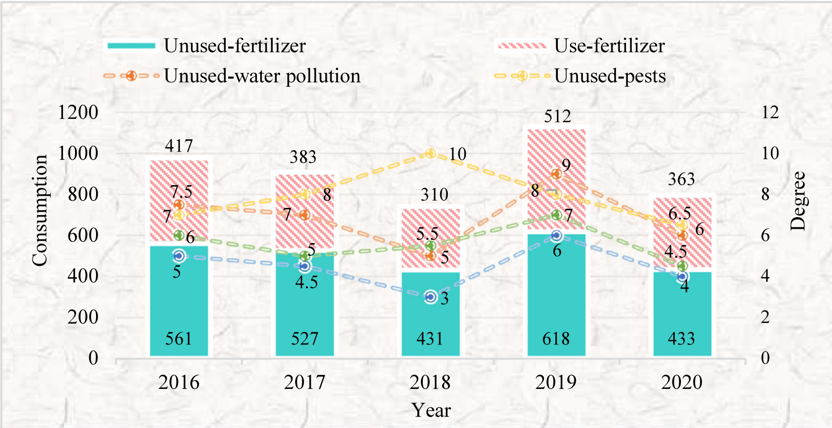


Fig. 1. Comparison of fertilizer consumption, water pollution and pests.

degree, pest degree, carbon and nitrogen absorption, and agricultural economic benefits. Through the statistics of various indicators in the agricultural ecosystem, the dynamic changes of the indicator data before and after the introduction of the agricultural ecological management system in rural areas are analyzed, so as to study the impact of the agricultural ecological management system on the rural agricultural ecosystem.

4. Data analysis of agricultural and rural ecological management system

4.1. Impact of agricultural ecological management system on fertilizer consumption, water pollution and pests

The experiment counts the consumption of fertilizers in the area of farmland in the rural areas that use the management system and the rural areas that do not use the management system from 2016 to 2020, as well as the changes in the degree of water pollution in the area, and the situation of crop pests. The degree of water pollution and pests are expressed in 10 degrees, from 1 to 10 respectively indicating the degree from light to heavy. The statistical results are shown in Table 1. The fertilizer consumption unit is kg/m^2.

According to the data in Table 1, we can compare and analyze the fertilizer consumption, water pollution and insect pests in the two rural areas. It can be seen that the rural fertilizer consumption, water pollution and insect pests using the agricultural ecological management system are better than the use of many rural ecological management system of agriculture. In order to analyze the data in the table more intuitively, we convert the data in the table into graphics, and the final result is shown in Fig. 1.

According to the data in Fig. 1, we can see the fertilizer consumption, water pollution and insect pests in the two rural areas. From the perspective of time, the consumption of chemical fertilizer in the two rural areas in 2020 is 433 kg/m^2 and 363 kg/m^2, and the water pollution degree and insect pest degree are 4.5, 6.5 and 4, 4.5 respectively, which are all reduced compared with 2016. From the perspective of the two rural areas, the consumption of chemical fertilizer in the rural area using the ecological management system in 2020 will be 70 kg/m^2 less than that in the other rural area, and the water pollution and pest situation will be two degrees lower than the other rural area. It can be seen that the agricultural ecological management system has a good control effect on the consumption of chemical fertilizers in rural areas, and effectively controls the degree of water pollution and insect pests.

4.2. Impact of agricultural ecological management system on rural carbon and nitrogen absorption

(1) Changes in the carbon content of agricultural ecosystems

Table 2
Statistics of dynamic changes in carbon content.

	Carbon input	Carbon output	Carbon absorption
2016	1750	2649	−899
2017	2280	3011	−731
2018	2013	2213	−200
2019	1494	1328	166
2020	1532	1291	241

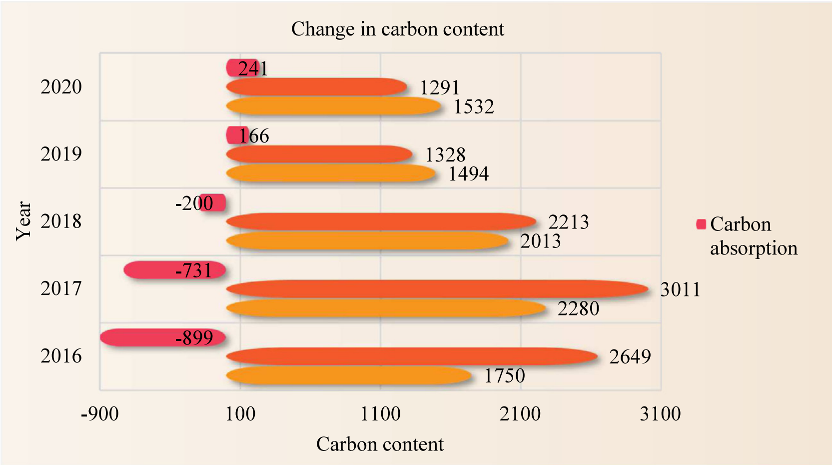


Fig. 2. Dynamic changes of carbon content in agricultural ecosystem.

Table 3
Dynamic changes of nitrogen content.

	Nitrogen input	Nitrogen output	Nitrogen absorption
2016	3581	2746	835
2017	3128	2213	915
2018	2759	1783	976
2019	3241	2107	1134
2020	2974	1544	1430

The area of a rural agro-ecosystems 2016 — carbon input during 2020, carbon output and net loss of carbon sequestration situation statistics, in 2018 the introduction of rural agro-ecological management system on agricultural ecosystem management, analysis of carbon content before and after the rural agro-ecological management system is introduced. The final statistical results are shown in Table 2, unit: mt.

According to the data in Table 2, we can see that the rural agro-ecosystem had a large net carbon loss before 2018, and the net carbon loss of the rural agro-ecosystem gradually decreased after 2018. We converted the data in Table 2 into graph form for a more intuitive observation of the carbon content, and the final result is shown in Fig. 2.

According to the data and graphical changes in Fig. 2, we can see that before the introduction of the agro-ecological management system, the rural area lost 899 mt and 731 mt of carbon absorption. From 2019 to 2020, due to the introduction of the agro-ecological management system, the rural carbon uptake gradually increased, and the carbon absorption amount becomes 166 mt 241 mt. And starting in 2019, carbon input began to exceed carbon output. It can be seen that the agro-ecological management system has a better regulating effect on the carbon content absorption in rural areas.

(2) Changes in nitrogen content in agricultural ecosystems

Statistics on the nitrogen input, nitrogen output and nitrogen absorption of the rural agro-ecosystem from 2016 to 2020, and analysis of the impact of the rural agro-ecological management system on the nitrogen absorption in the agro-ecosystem. The statistical results of the most households are shown in Table 3, in mt.

According to the data in Table 3, we can see that the nitrogen uptake of the rural agro-ecosystem has always been a positive number, indicating that the rural agro-ecosystem has better nitrogen absorption performance. Convert the data in the table into graphs to observe and analyze them. The final result is shown in Fig. 3.

According to the data in Fig. 3, we can see that the nitrogen absorption of the farm before the introduction of the agro-ecological management system was 835 mt and 915 mt. After the introduction of the agro-ecological management system, the farm's nitrogen absorption has changed significantly in 2019 and 2020. The annual nitrogen uptake was 1134 mt and

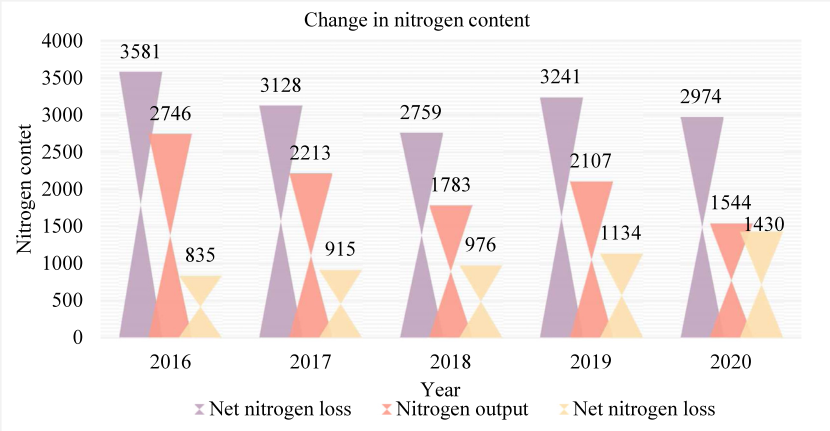


Fig. 3. Dynamic changes of nitrogen content.

Table 4
Economic income of rural agriculture.

	Village A	Village B	Village C	Village D	Village E
2016	291	287	262	537	520
2017	276	276	241	469	481
2018	267	270	300	518	510
2019	313	316	291	543	557
2020	355	348	350	614	637

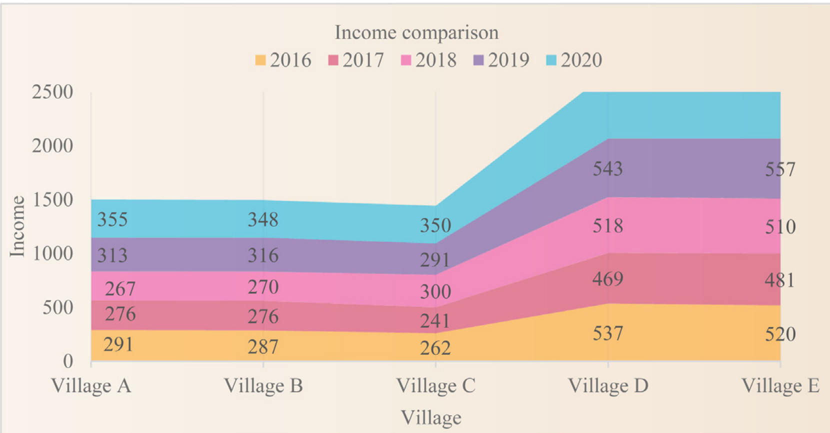


Fig. 4. Comparison of rural agricultural economic benefits.

1430 mt, respectively, an increase of 158 mt and 296 mt compared to the previous year's nitrogen uptake. It can be seen that the agricultural ecological management system has a good regulatory effect on the nitrogen absorption of the agricultural ecosystem.

4.3. Influence of agricultural ecological management system on rural agricultural economic benefits

In this study, the economic benefits of five rural areas in the region in recent five years were statistically analyzed. Among them, rural D and rural E introduced agricultural ecological management system to manage agricultural ecosystem, and rural A, B, C managed agricultural ecosystem according to the traditional mode. The final results are shown in Table 4, unit: 10 000.

According to the data in Table 4, we can see that the agricultural economic benefits of rural A, B and C are less than those of rural D and rural E, and the income difference is large. The economic benefits of the five rural areas are transformed into a graph for observation. The final result is shown in Fig. 4.

According to the data in Fig. 4, we can see that the economic benefits of rural A, B and C without introducing the agricultural ecological management system are far less than those of rural D and E with the introduction of agricultural ecological management system. From the use of agricultural ecological management system to analyze the overall income of five rural areas in two cases, in 2020, the total agricultural economic income of three rural areas without introducing agricultural ecological management system was 1053 thousand, while that of rural D and rural E was 1251 thousand, 198 thousand more than the other three rural areas. From the analysis of single rural economic benefits, the total agricultural economic returns of rural A, B and C in five years are 1502 thousand, 1497 thousand and 1444 thousand, respectively, and that of rural D and E in five years are 2681 thousand and 2705 thousand respectively. It can be seen that the agricultural ecological management system has a certain role in promoting rural agricultural economy.

5. Conclusions

Agriculture is our country's basic industry. Agriculture has been affecting the development of our country's economy, society and ecological environment since a long time ago. Through the management of the agricultural ecosystem, it can effectively improve the environmental problems of the rural ecosystem, promote the development of the rural economy, and have a certain effect on improving the living standards of farmers.

This research uses big data mining technology to collect and process the relevant data of the rural agricultural ecosystem, uses the complex system theory to analyze and understand the agricultural ecosystem, and finally builds an indicator system for the ecological management system to measure fertilizer consumption and water pollution. The degree, insect pest degree, carbon and nitrogen absorption and agricultural economic benefits are the indicators of the ecological management system to analyze the impact of the ecological management system on the rural agricultural ecosystem.

The final results show that the agricultural ecological management system can effectively control the fertilizer consumption in the agricultural ecosystem, and reduce the water pollution and the degree of pests in the agricultural ecosystem. The agro-ecological management system can also promote the absorption of carbon and nitrogen in the agro-ecosystem, and promote the development of rural agricultural economy and improve the economic benefits of rural agriculture.

CRediT authorship contribution statement

Fazheng Chen: Data curation, Writing - original draft. **Yuanhong Hu:** Visualization, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

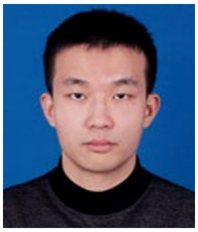
References

Agrawal, A., Choudhary, A., 2016. Perspective: Materials informatics and big data: Realization of the "fourth paradigm" of science in materials science. APL Mater. 4 (5), 208–209.
Blanco, J., Michon, G., Carriere, S.M., 2017. Natural ecosystem mimicry in traditional dryland agroecosystems: Insights from an empirical and holistic approach. J. Environ. Manag. 204 (1), 111–122.
Chen, L., Yuan, X., Wang, Z., et al., 2016. A redox-responsive complex system based on 2D shape-persistent cyclo aramide and ferrocenium. Asian J. Org. Chem. 5 (8), 966–970.
Ciftcioglu, Cetinkaya G., 2017. Assessment of the resilience of socio-ecological production landscapes and seascapes: A case study from Lefke Region of North Cyprus. Ecol. Indic. 73 (FEB.), 128–138.
Danzer, C., Vallon, M., Wukisiewitsch, W., et al., 2016. Powertrain synthesis for the design of complex system configurations. Mtz Worldwide 77 (9), 42–47.
Deng, L., Li, D., Cai, Z., et al., 2020. A QoS optimization system for complex data cross-domain request based on neural blockchain structure. Neural Comput. Appl. 32, 16455–16469.
Dubey, R., Gunasekaran, A., Childe, S.J., et al., 2016. The impact of big data on world-class sustainable manufacturing. Int. J. Adv. Manuf. Technol. 84 (1–4), 631–645.
Guan, Qingchun, Hao, Jinmin, Xu, Yueqing, et al., 2019. Agro-ecological management division based on the supply and demand of ecosystem services. Resour. Sci. 041 (007), 1359–1373.
He, Xue, Huang, Chaoyu, 2019. Intelligent management system of modern agricultural ecological park based on internet of things. Mach. Electron. 12 (9), 47–50.
Hossain, M.S., Ramirez, J., Szabo, S., et al., 2020. Participatory modelling for conceptualizing social-ecological system dynamics in the Bangladesh delta. Reg. Environ. Change 20 (1), 1–14.
Lopez-de Ipina, K., Barroso, N., Calvo, P.M., et al., 2020. Multilingual audio information management system based on semantic knowledge in complex environments. Neural Comput. Appl. 32, 17869–17886.
Jun, Zhang, Hui, Yuan, 2019. Research on the spatio-temporal changes of agricultural ecosystem service value. J. Chongqing Univ. Technol. Soci. Sci. 33 (04), 23–32.
Kune, R., Konugurthi, P.K., Agarwal, A., et al., 2016. The anatomy of big data computing. Softw. - Pract. Exp. 46 (1), 79–105.
Lammoglia, Sabine-Karen, Moeys, Julien, Barriuso, Enrique, 2017. Sequential use of the STICS crop model and of the MACRO pesticide fate model to simulate pesticides leaching in cropping systems. Environ. Sci. Pollut. Res. 24 (8), 6895–6909.

Mehra, Bharat, Sikes, Everette Scott, Singh, Vandana, 2020. Scenarios of technology use to promote community engagement: overcoming marginalization and bridging digital divides in the southern and central appalachian rural libraries. Inf. Process. Manag. 57 (3), 102129.
Pérez-Gutiérrez, Juan D., Paz, J.O., Tagert, M.L.M., 2017. Seasonal water quality changes in on-farm water storage systems in a south-central U.S. agricultural watershed. Agricult. Water Manag. 187 (1), 131–139.
Ray, D., Behera, M.D., Jacob, J., 2016. Predicting the distribution of rubber trees (Hevea brasiliensis) through ecological niche modelling with climate, soil, topography and socioeconomic factors. Ecol. Res. 31 (1), 75–91.
Santos, D., Renato, P., 2017. On the philosophy of bitcoin/blockchain technology: Is it a chaotic, complex system? Metaphilosophy 48 (5), 620–633.
Sheila, Joy, 2016. CIPP solution for major soft drink bottling plant's complex system. Trenchless Technol. 25 (4), 22–24.
Whyte, J., Stasis, A., Lindkvist, C., 2016. Managing change in the delivery of complex projects: Configuration management, asset information and 'big data'. Int. J. Proj. Manage. 34 (2), 339–351.
Wu, J., Guo, S., Li, J., et al., 2016. Big data meet green challenges: Big data toward green applications. IEEE Syst. J. 10 (3), 888–900.
Xie, Y.L., Xia, D.X., Ji, L., et al., 2017. An inexact stochastic-fuzzy optimization model for agricultural water allocation and land resources utilization management under considering effective rainfall. Ecol. Indic. 92 (SEP.), 301–311.
Xu, Z., Cheng, C., Sugumaran, V., 2020. Big data analytics of crime prevention and control based on image processing upon cloud computing. J. Surveillance Secur. Saf. 1, 16–33.
Yu, B.Y., Honda, T., Zubair, S.M., et al., 2016. A maintenance-focused approach to complex system design. Ai Edam Artif. Intell. Eng. Des. Anal. Manuf. 30 (03), 263–276.
Zhang, Huili, Cai, Jie, Xia, Xianli, 2018. Coupling and coordination analysis of soil erosion control benefits and ecological agriculture development. Trans. Chin. Soc. Agric. Eng. 34 (8), 162–169.
Zhenmian, Q., Bixia, C., Koji, N., 2016. Customary management system of irrigation ponds in Japan-a study in a globally important agricultural heritage systems (GIAHS) site of Noto Island, Ishikawa prefecture. J. Resour. Ecol. 7 (3), 205–210.
Zhou, L., Pan, S., Wang, J., et al., 2017. Machine learning on big data: Opportunities and challenges. Neurocomputing 237 (MAY10), 350–361.

FaZheng Chen was born in Puding, Guizhou. P.R. China, in 1982. He received the bachelor's degree from Guizhou Normal University, P.R. China. Now, he studies in College of History and Ethnic Culture, Guizhou University. His research interest include national culture and ecological management.

E-mail: aschenfazheng123@163.com.



Yuanhong Hu was born in Hefei, Anhui. P.R. China, in 1990. He received the bachelor's degree from Nanjing University of Finance and Economics, P.R. China. Now, he studies in College of Business, Shanghai University of Finance and Economics. His research interest include international economics, environmental economics and public management.

E-mail: hover_hyh@yeah.net.