An Agent-based Simulation of Farmer's Behaviors Adapting to Ecological Policies Using NetLogo

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***Abstract*—Agent-based simulation, a methodology based on Complex Adaptive System (CAS) theory, is considered to be a new approach to research the farmer's behaviors adapting to ecological policies. Based on the analysis that the farmer is a complex system, we classified them into five kinds. This paper used NetLogo software to simulate how financial subsidies affect their behavior change. The results show that when financial subsidies increase the farmer's income largely, the proportion of those violate the policies will reduce significantly by 96.2%, and when financial subsidies decrease the income largely, the proportion of those who obey the policies will reduce significantly by 97.9%.**

Keywords- human behavior; CAS Theory; NetLogo

I. INTRODUCTION

Complex Adaptive System (CAS) is composed of many interacting parts, giving rise to emergent patterns of behavior. Each CAS is formed of many interacting agents. From the local interaction of individual agents arises a global behavior or a pattern that cannot be predicted at the local level. In such systems order can emerge through a process of self-organization [1]. The study of CAS has been applied to different fields such as economies, organizations, ecologies, biology, the immune system and the brain [2-4].

The Northern farming-pastoral zone of China is a transition zone of the sub-humid farming area and semi-arid pastoral area. The geographical features of this area are arid and windy, water shortage, sandy desertification, soil erosion, natural disasters clusters [5]. Because of ecological vulnerability and human long-term unreasonable use, a series of serious ecological problems have appeared in this area. Generally speaking, human factors have a decisive impact on ecological degradation. Farmer is the basic unit of production and decision-making in rural areas. If policy makers can insight into this interaction and feedback mechanism, they will obtain new ideas and methods for their research [6].

II. THE GENERALITY OF THE STUDY REGION

Yanchi County is located in the eastern part of Ningxia Hui Autonomous Region, which adjoins Inner Mongolia Autonomous Region on the north, meets Shaanxi Province in the east side, and in the side of Gansu Province in the south side.

Yanchi County is a transition zone from loess plateau to Ordos platform, from semi-arid area to arid area, from steppe to desert steppe, and from agricultural area to pastoral area. This geographic transitional characteristics cause vulnerability and diversity of this area's natural conditions and resources. Yanchi County is drought, wind and sandy, and the comprehensive climatic indices are as follows: the annual strong wind day number of above eight grade is 23.4, annual mean temperature 9.2℃, annual sunshine time 3124h, frostless period 148 d, annual precipitation 680 mm, evaporation 2897 mm.

III. THEORY AND METHOD

A. CAS Theory

With the development of system theory, cybernetics, complexity theory and especially computer science and technology, people are no longer satisfied with the simple and linear analysis standard model to study natural science, but use system paradigm combined with integrity, complexity, non-linear, and dynamic to study social science.

Complex adaptive system (CAS) theory grew up in this context. In theory, it shows clear direction of the development of biological, physical, social, economic, military and other fields, and in method, it opened a new era in simulation based on intelligent agents.

The basic idea of CAS theory is as follow: The system is consisted of adaptive agents that can change its own structure and behavior style with long term "study" and "grow". The interactions of subject with subject and subject with environment can emerge new structures and more complex behaviors.

The characteristics of CAS Theory are as follows:

- Emphasize agent's initiative, intelligence and adaptability. While emphasizing holistic view, CAS Theory does not negate the attributes of individual's vitality and movement changes. This is the basic distinction between CAS Theory and system theory.
- Put forward a new understanding of the macro and micro perspective—emerged. Emergence is the mutation of system function and structure caused by the part interaction between individuals. This point was strongly excluded by the traditional concept of the system theory, and couldn't be explained by traditional statistical and quantitative methods, but it provides new ideas for biological, social, economic, and other complex systems phenomena.
- The system is open and operational. CAS theory is universal, and it can be used to summary almost all of

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the complex systems from engineering to human society. CAS Theory is developed along with computer science and technology and has strong operability.

B. NetLogo

Originally being more designed for teaching, NetLogo is increasingly used for research. It is easy to learn, provides powerful concepts for implementing ABMs, and it has continuously been supported by its developers and a large and growing user community for more than ten years.

NetLogo is written in Java language and can be run on all major platforms (Mac, Windows, Linux, etc.). In addition, individual models can be run as Java applets inside web pages. NetLogo is freeware and can be downloaded from the next web address: http://ccl.northwestern.edu/netlogo/.

NetLogo uses three types of agents: turtles, patches and observer. Turtles are agents that are moving inside the world. The world is a bi-dimensional lattice composed by patches. The observer does not have a specific location--we can imagine it like an entity that observes the world composed by turtles and patches.

The interface of NetLogo is as figure 1.

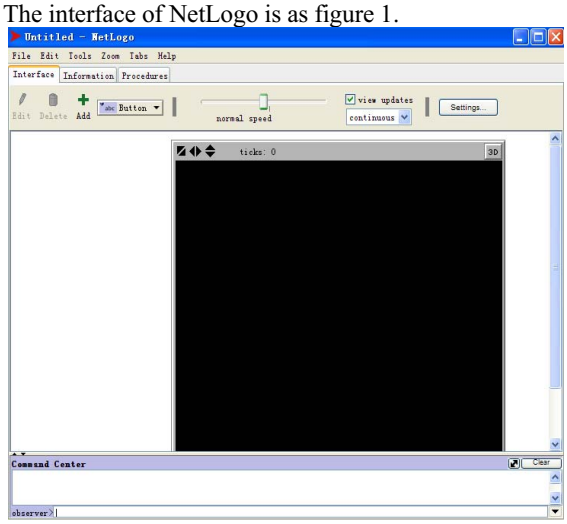

Figure 1. The interface of NetLogo

IV. BEHAVIOR AND SIMULATION RULES

A. Behavior Theory

- Herd behavior. It refers to that the individual, under the pressure of social masses, changes one's own attitude and gives up one's original opinion to take the behavior in accordance to that of the majority. mainly for two reasons: first, when people make judgments on things, they rely on the experience of their own and information provided by the others. Especially when lacking of knowledge and experience, they are easily influenced by others; second, people have affiliation need. In general, people who tend to consistent with the majority in the same group will not be too embarrassing, on the contrary, the unconventional tend to be isolated and punished.
- Benefits behaviors. Avoiding disadvantages is human nature. When some behavior can bring reward he would get positive reinforcement, and when some behavior can bring its punishment, he received negative reinforcement. This nature has significant cognitive characteristics, and can be judged according to their own experience, interest in the effect of the behavioral consequences might bring. This nature has significant cognitive characteristics, and can be judged according to their own experience, so as to get maximum profit.

B. Agent Classification

Farmers can be classified into five kinds as follows: executors, outside workers, immigrants, sideline-developers, and violators. As an important mean to arouse people's enthusiasm to carry out policies, financial subsidies can significantly affect the proportion of the five kinds of people. According to our survey, in the case that the income is not affected by the policy, the proportion was 61.4%, 14.0%, 7.2%, 8.2% and 9.2% respectively. By analyzing the questionnaires, we obtained that the change parameters alone with financial subsidies of the five kinds of people are 0.319, -0.064, -0.063, -0.083 and -0.109 respectively.

The proportions of executors, outside workers, immigrants, sideline-developers, violators can be assumed as Y_1, Y_2, Y_3, Y_4, Y_5 respectively, and the rate of income change as X. So, their function relations are as follows:

$$Y_1 = 61.4\% + 0.319X \quad (1)$$

$$Y_2 = 14.0\% - 0.064X \quad (2)$$

$$Y_3 = 7.2\% - 0.063X \quad (3)$$

$$Y_4 = 8.2\% - 0.083X \quad (4)$$

$$Y_5 = 9.2\% - 0.109\,X \quad (5)$$

C. Simulation Rules

At a time t, individual i and its surrounding 8-individual neighborhood exchange views, and i can be influenced by them. Suppose that the number of this five kind of people in this nine lattices is p, g, y, b and r respectively. The rules are as follows:

- Case 1, the executor locates at the center, and its 8 neighborhoods:
  If there is a maximum among p-2, g, y, b and r, i becomes that kind, otherwise, i doesn't change.
- Case 2, the outside worker locates at the center, and its 8 neighborhoods:
  If there is a maximum among p-2, g+1, y, b and r, i becomes that kind, otherwise, i doesn't change.
- Case 3, the immigrant locates at the center, and its 8 neighborhoods:
  If there is a maximum among p-2, g, y+1, b and r, i becomes that kind, otherwise, i doesn't change.

- Case 4, the sideline-developer locates at the center, and its 8 neighborhoods:
  If there is a maximum among p-2, g, y, b+1 and r, i becomes that kind, otherwise, i doesn't change.
- Case 5, the violator locates at the center, and its 8 neighborhoods:
  If there is a maximum among p-2, g, y, b and r+1, i becomes that kind, otherwise, i doesn't change.

V. RESULTS ANALYSIS

According to color from deep to shallow, we use five gray scales to denote executor, outside worker, immigrant, sideline-developer, and violator respectively. The total number of people is 10201.

Case 1: when financial subsidy doesn't influence farmer's income, at the beginning and end the interface of NetLogo are as figure 2.

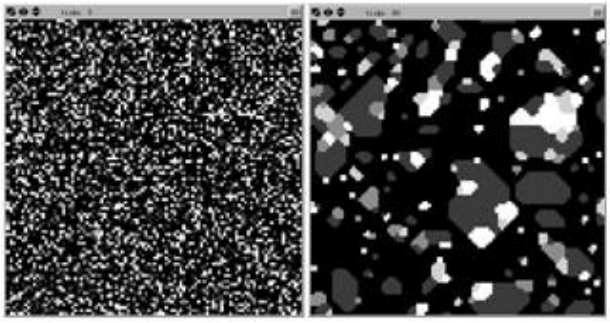

Figure 2. The interface at the beginning and end

The quantitative change is as figure 3.

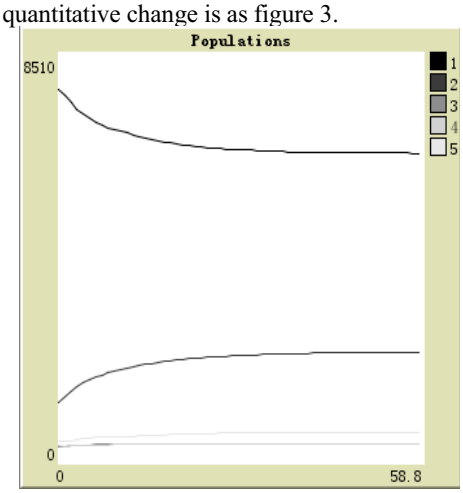

Figure 3. Quantitative change

Case 2: when financial subsidies increase the farmer's income small, at the beginning and end the interface of NetLogo are as figure 4.

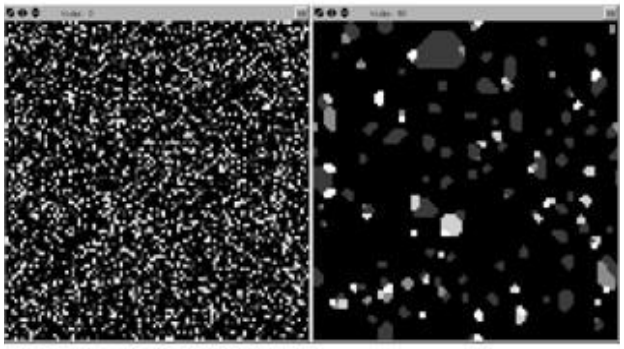

Figure 4. The interface at the beginning and end

The quantitative change is as figure 5.

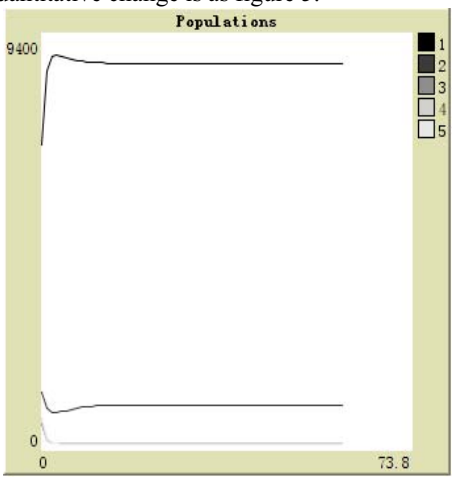

Figure 5. Quantitative change

Case 3: when financial subsidies increase the farmer's income greatly, at the beginning and end the interface of NetLogo are as figure 6.

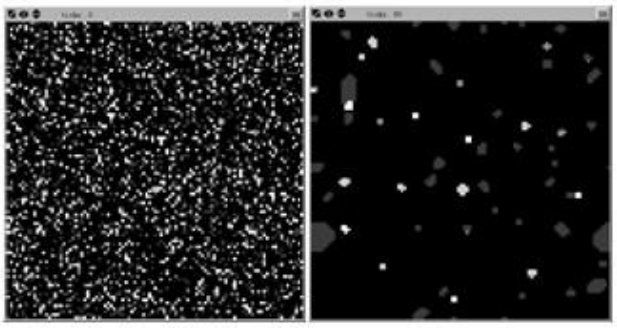

Figure 6. The interface at the beginning and end

The quantitative change is as figure 7.

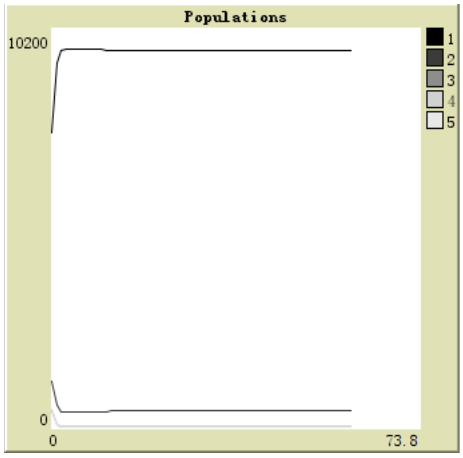

Figure 7. Quantitative change

Case 4: when financial subsidies decrease the farmer's income small, at the beginning and end the interface of NetLogo are as figure 8.

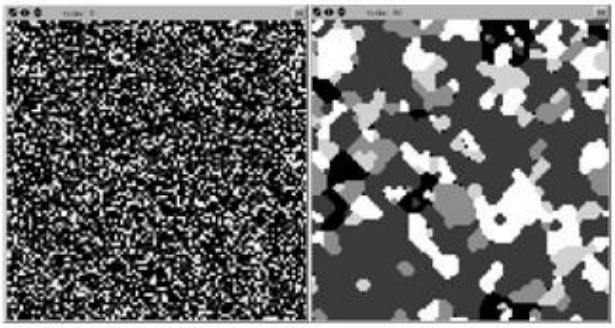

Figure 8. The interface at the beginning and end

The quantitative change is as figure 9.

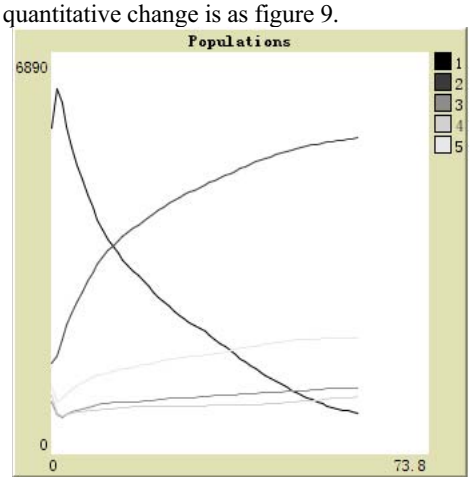

Figure 9. Quantitative change

Case 5: when financial subsidies decrease the farmer's income greatly, at the beginning and end the interface of NetLogo are as figure 10.

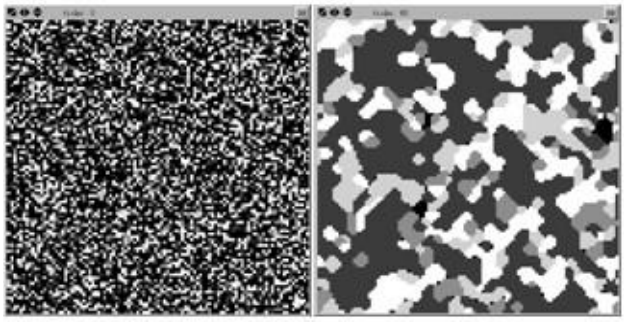

Figure 10. The interface at the beginning and end

The quantitative change is as figure 11.

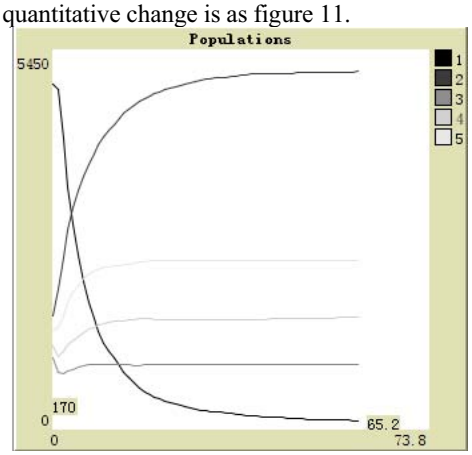

Figure 11. Quantitative change

VI. CONCLUSIONS

Through research we found that NetLogo can simulate farmer's behaviors effectively. It shows that when financial subsidies increase the income of the farmers largely, the proportion of those violate the policies will reduce significantly by 96.2%, and when financial subsidies decrease the income of the farmers largely, the proportion of those who obey the policies will reduce significantly by 97.9%.

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