The Complex Adaptive System of Rural Tourism

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Complex adaptive systems (CAS) theory was proposed by John Holland in 1994 and mainly studies the mechanisms of a system's complexity and system emergence. The core of the theory is "adaptability produces complexity", and the adaptive interaction of microscopic agents can produce macroscopic complexity phenomena. The theory believes that the system is a dynamic network composed of interacting and adaptable agents. Adaptive agents are capable of "learning" and "growing" in order to obtain the maximum symbiotic benefits. Agents can adjust behavior rules to meet changes in the external environment and other agents' requirements in the process of interacting with the information, energy, and matter of the external environment. They move or aggregate to occupy a better niche and obtain the greatest benefits in symbiosis. The overall differentiation, aggregation, and reconstruction of the system are gradually derived on the basis of the interactions between the agents and the environment. Along with the dynamic adaptability process, the whole system leaps from chaos to order and from simple to complex .

complex adaptive system (CAS) rural tourism system

1. Overview of Complex Adaptive Systems Theory

Complex adaptive systems (CAS) theory was proposed by John Holland in 1994 and mainly studies the mechanisms of a system's complexity and system emergence. The core of the theory is "adaptability produces complexity", and the adaptive interaction of microscopic agents can produce macroscopic complexity phenomena [33]. The theory believes that the system is a dynamic network composed of interacting and adaptable agents. Adaptive agents are capable of "learning" and "growing" in order to obtain the maximum symbiotic benefits [33]. Agents can adjust behavior rules to meet changes in the external environment and other agents' requirements in the process of interacting with the information, energy, and matter of the external environment. They move or aggregate to occupy a better niche and obtain the greatest benefits in symbiosis [33]. The overall differentiation, aggregation, and reconstruction of the system are gradually derived on the basis of the interactions between the agents and the environment [32]. Along with the dynamic adaptability process, the whole system leaps from chaos to order and from simple to complex [47].

The CAS theory puts forward two models: the basic behavior model of individual evolution and the echo model of overall evolution. Microscopically, to satisfy their own survival and development, adaptive agents follow the internal strategy model of "if–then" in their interaction with other agents and the external environment, and they constantly learn and accumulate experience to modify their own adaptive behavior. Multiple agents produce behavioral

responses and adjustments with the process of “external environment-agents cognition-adaptive adjustment”. Different levels of agents’ learning or innovation ability lead to differences in the behavioral effects of the same type of agent (**Figure 1**).

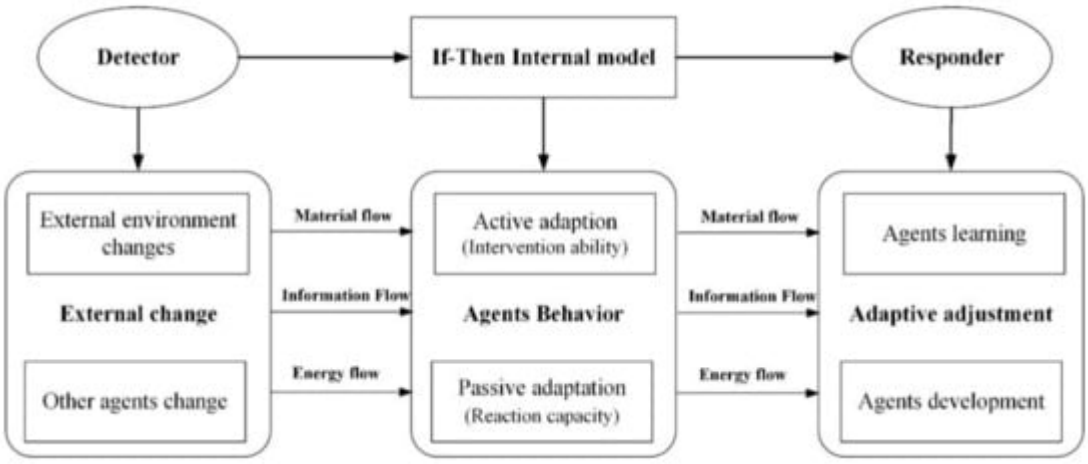

Figure 1. Behavioral model of adaptive agents.

Macroscopically, the echo model of “agents-context-agents” is constructed to link individual evolution and system evolution. An echo is an agent-based, microsimulation model in which “agents” interact within a “site” located in a “world”. The emergent behavior of the world is due to the interactions of the individual agents. The world provides a spatial and temporal context for agents that reside at specific sites [24]. Resources are the basis of system evolution, and location is the spatial place of the subject’s activities. The world consists of several sites, and multiple agents are in different spatial sites that have a fountain with various experiences and resources, which constitute the basis of individual adaptability [33]. The ability to acquire resources from either site or other agents allows an agent to reproduce. Since the environment is continuously changing, new agent types evolve; thus, the patterns of exchange between agents will also evolve [24].

There are complex and diverse nonlinear interactions between agents and the environment, which affect the change of external environmental state and feedback to the behavioral response mode of agents, further promoting the process of the aggregation, diffusion, and reconstruction of the scale of spatial clusters and upgrading the overall evolution of the system layer by layer [33]. The internal structure of systems evolves, and cycles promote the emergence of the system. The macro system generates new elements, structures, and functions and evolves from one complex condition to another [32]. It is a “bottom-up” process arising when the collective behavior of interacting individuals results in a system or part of a system that adapts and creates an emergent order [34].

2. Composition and Characteristics of the Rural Tourism Complex Adaptation System

Holland characterizes seven basic elements of CAS. These seven characteristics consist of four properties—aggregation, nonlinearity, diversity, and flows, and three mechanisms—tagging, internal models, and building

blocks [33] (**Table 1**). The rural tourism system is an open and complex giant system with chaotic characteristics and multiple subsystems. It is characterized by subjectivity, adaptability, self-organization, and dynamic balance [17,31], which agrees with the basic idea of the CAS theory [33] (**Table 1**).

Table 1. Compatibility analysis between rural tourism systems and main properties of the CAS theory.

Element	Characteristic Interpretation	Compatibility Interpretation of Rural Tourism System
Aggregation	Aggregation of agents can form meta-agents, and meta-agents are reaggregated to form meta-meta-agents. The hierarchical organization of CAS is formed, producing complex phenomena.	Rural agents are aggregated to different scales, types, and levels of rural meta-agents such as tourism spots, tourism facilities, and tourism communities, which constitute the rural tourism system as subsystems.
Tagging	Different hierarchical systems have multiple tags, which can not only promote the “adhesion” of agents but also be used for the “reproduction” of agents.	Tourism image, core attractions, major projects, key policies, etc., can all constitute tags, which promote the derivation, differentiation, and gathering of villagers, citizens, enterprises, and tourists.
Flow	Many nodes and connectors form a resource flow network, and the cycle of resources has a multiplier effect.	Rural tourism destination system agents are connected with each other and the external environment through passenger flows, information flows, material flows, and capital flows.
Nonlinearity	The interaction between agents and environment is nonlinear and promotes the complex transition of the system.	The rural system evolutionary process shows complex evolutionary characteristics such as fluctuation, mutation, and emergence, and new system agents, elements, structural functions, and spatial patterns are apparent.
Diversity	Each new adaptation of agents opens up a new ecological niche, promotes further interaction, and thus brings about the emergence of diversified systems.	The continuous succession of external environment, tourism demand, tourism supply, and participants promote the formation of rural tourism with different modes, scales, and functions.
Internal model	Based on experience and learning ability, the agents bitterly adapt to the perpetual novelty environment and transform the adaptation behaviors into an internal model to guide the next adaptation. There are tacit and overt models.	In rural tourism, the tacit model is the choice of villagers’ livelihood strategy, enterprise management strategy, government planning, and control, while the overt model is the tourism product type and the spatial pattern of rural tourism.
Building blocks	Blocks are coupled according to spatial location and interactive action to build the hierarchy and complexity of the system. The higher-level rules are derived from the lower-level building blocks.	Rural tourism subsystems and elements constitute the building blocks of high-hierarchy systems. The formation and development, combination and dissolution, and competition

Element	Characteristic Interpretation	Compatibility Interpretation of Rural Tourism System
		and cooperation of rural tourism “blocks” reflect the evolutionary process of rural tourism.

facilities, ion of the stems are interrelated, and through the exchange of material, energy, and information, an orderly rise in the development level of the rural tourism system and the dynamic optimization of the spatial agglomeration pattern are realized.

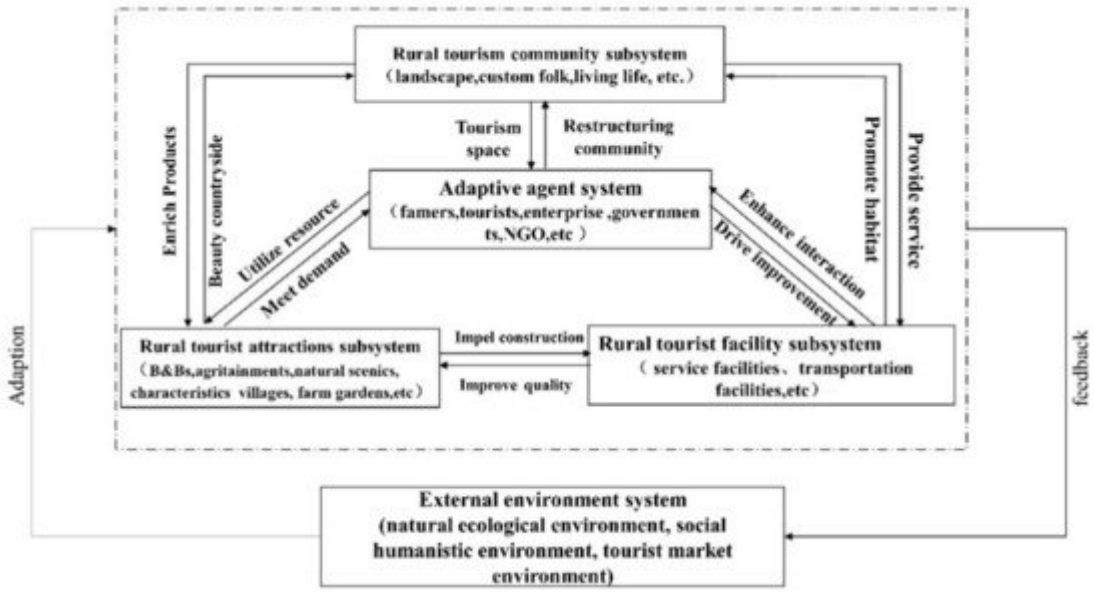

Figure 2. Composition of a complex adaptation system in a rural tourism destination.

The core attraction or the tourism image tags guides the government, enterprises, villagers, tourists, and other agents to execute the “internal model” according to their own “resource pool” in order to generate adaptive behavior to match other adaptive agents and the external environment, etc.; this promotes the generation, development, and spatial agglomeration of “building blocks” such as diversified rural tourism attractions, tourism facilities, and multiple agents. There is a “nonlinear” development in the aggregation process of agents and the transmission process of element flows, and the “nonlinear” interaction process promotes the emergence of rural tourism product types, spatial states, and functional structures [48] (**Table 1**).

3. Complex Adaptive Mechanism of Evolution of Rural Tourism

On the microlevel, multiple agents detect environmental conditions and engage in adaptive behaviors. Under the disturbance of the natural geographical environment, socioeconomic environment, market demand environment, and other unexpected events, villagers, government, enterprises, tourists, and other agents actively adapt to the environment and show different behavioral patterns (**Figure 3**). At the same time, to coexist in a better system, agents can correct the behavioral pattern according to the behavioral effect [46]. In the process of adaptation, agents interact with each other and gather in rural areas with beautiful environments, perfect facilities, and prominent locations, forming a number of rural tourism spatial clusters [28].

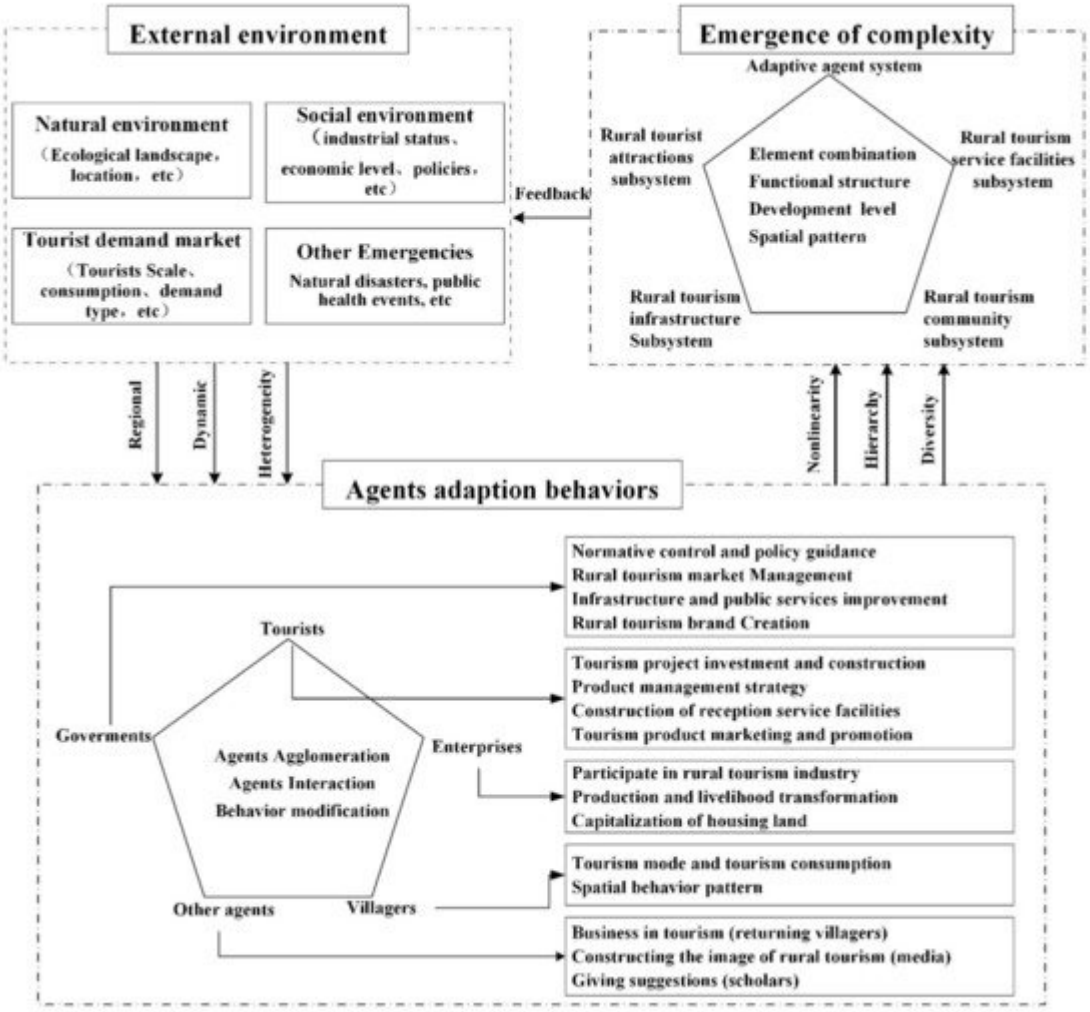

Figure 3. Adaptive behavior and echo model of multiple agents in a rural tourism destination system.

On the macro level, the adaptive behavior of the agent promotes the complex evolution of the system. First, when the external environment changes, diversified adaptation strategies and degrees are shown by agents with differences in statistical characteristics, learning ability, and resources [36], which influence the direction and speed of the evolution of the rural tourism system. Second, there are nonlinear interactions between agents and the environment. The evolution of the rural tourism destination system is characterized by “short-term oscillation”, “long-term cycle”, “fluctuation and bifurcation”, and other development processes [49]. Finally, the spatial agglomeration of agents has different levels such as the scenic area scale, village scale, town scale, and county scale. The spatial agglomeration of agents at a lower level constitutes a spatial agglomeration at a higher level as “building blocks”. The higher levels of rural tourism development and spatial pattern are derived from the low-level subsystems. When the individual behavior strategy changes dynamically, it will affect the overall structure and function of the rural tourism system step by step [33]. The diversity, nonlinearity, and hierarchy of the agents’ response processes promote the complex evolution of the rural tourism destination system. New elements, functional structures, development levels, and spatial patterns emerge [50], which are fed back to the external environment, and the agents further revise the adaptation strategy and behavioral response, thus promoting the formation of more complex agent behaviors (**Figure 3**).

The cyclic process of “environmental state-agent adaptation-system evolution-environmental feedback” promotes the spiral development of rural tourism destination systems. As the level of the national economy and transportation improves, the element flow scale expands, multiple agents interact frequently, and the number, scale, and quality of rural tourism increase. More agents participate in the development of the rural tourism industry, which drives the orderly development of the rural tourism destination system and the dynamic optimization of spatial patterns.