

ON EVOLUTION OF MAN-LAND SYSTEM IN OASIS —Taking Minqin Basin as a Case

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ABSTRACT: Human beings have had a tremendous impact on natural ecosystems and are now the principal power to change the biosphere. It is logical that we should pay close attention to the interaction between human systems and environmental systems. Taking Minqin basin, Gansu Province, as a case, this paper focuses on the evolution of regional physical environments and the cultural systems by which people maintain their relationships with those environments. This paper presents the conceptual framework for the man-land system. Expecting to accelerate the regional sustainable development, it also analyses the evolutionary mechanism of regional man-land system. On the basis of reviewing and analyzing the evolution of man-land system in Minqin basin, the paper also brings forward an adjusting mode for the studied area, which consists of three aspects: to build up a concept that economic growth must harmonize with environmental quality's and land productivity's improvement; to make a whole planning and management in the drainage area; and to push forward the technique of water-saving irrigation and establish water-saving agricultural system. It's meaningful for resource exploitation and sustainable development of Chinese northwestern arid area, which is represented by Minqin basin, by understanding what great changes the basin has experienced and is experiencing at the global background, and studying its time order and territorial structure, the system's character and law of evolution, trend and the regulating ways to improve man-land relationship.

KEY WORDS: Minqin basin; man-land system; man-land relationship; oasis

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1 INTRODUCTION

Man-land system, or territorial system of man-land relationship, is a dynamic system developed in specific territorial range as a production of the interaction and interrelation between man and land. The research on the evolution of man-land system aims at providing basis to optimize and regulate the man-land structure and to strengthen the system's function by the means of exploring the system's developmental law in medium-small dimension (LIAO, 1992).

On account of its typicality, the Minqin basin is selected — it is territorially characteristic and formed through a complex process. Located in the lower reaches of the Shiyang River, which is in the eastern part of Hexi Corridor region of Gansu Province, the basin is at an altitude of 1200 – 1500m and most is covered by

desert. There is only 152 000ha arable land, which occupies 9% of the total area. Because of the arid continental climate of temperate zone, its aridity is above 24, which results in spare vegetation species and frequent natural disasters, especially windblown sand. The ecological environment is fragile. Surrounded by small hills and desert, the basin is high at its edge, whereas the inner part is alluvial plain for oasis agriculture (Fig. 1).

The human character in the Minqin basin is also unique, which is reflected in many cultural relics. Original habitants created colorful antique culture here in the Holocene epoch when mankind society transferred from primitive to civilized period. From more than 2000a B. P. on, the Minqin basin became a strategic area in defense and transportation pivot of many dynasties. Since the Minqin basin is a representative area

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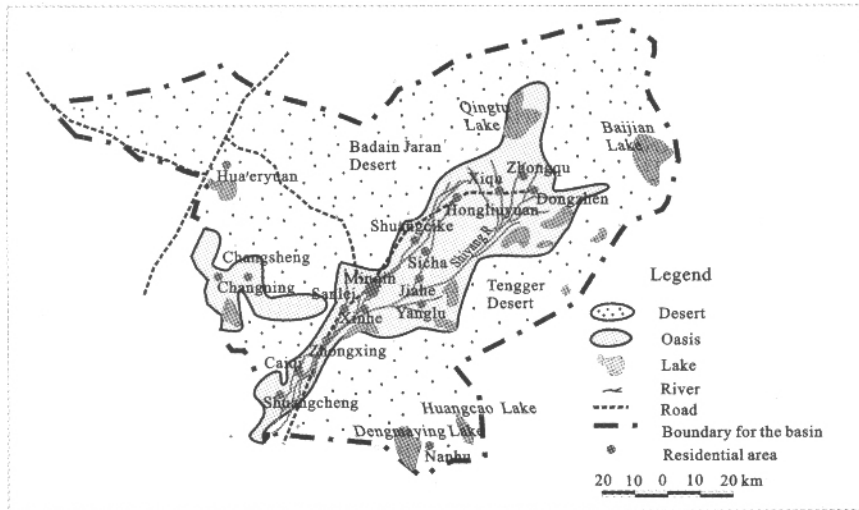


Fig. 1 The schematic map of Minqin basin

in Chinese northwestern arid area, the study on it is very meaningful and instructive for resource exploitation and sustainable development of Chinese northwest.

2 BASIC CONTENTS OF THE MAN-LAND INTERACTIONS IN MINQIN BASIN

2.1 Primitive Times (5000 – 2200a B. P.) — Dependence Type

This period was the Neolithic Age before the Western Han Dynasty when the climate was relatively mild and humid for that it was in the semi-stable period of the mid-Holocene epoch, and the mild and humid climate fluctuated often. At that time, an ancient terminal lake was formed at the lower reaches of the ancient Shiyang River and the Jinchuan River. It was large in area in the early period (the east-west width is 120km) while somewhat small in the later period and was called the “Zhuye Marsh” in historical book “Yugong” (475 B. C. to 221 B. C.).

The relatively advantageous environment provided superior conditions for human activities and significantly improved the level of human civilization, which is shown in 3 aspects: 1) The territorial enlargement of human activities. Almost all places of better environment contained relics of ancient human civilizations in this phase. 2) Diversity in social relationship. 3) Great improvement of productivity, although they were still low. Especially, social structure and ability to remold physical environment had not formed yet, thus the range of single human activity was limited and had to depend on nature and its change. In other words, nature’s effect

on human activities was significant.

2.2 Historical Times (2200a B. P. – 1950s) — Interference Type

Natural environment and human environment changed greatly in this period. Human activities on one hand conformed negatively to and, on the other hand, interfered positively. It’s very clear that the climate became warmer and drier in this period. The “Zhuye Marsh” began to divide into east and west lakes in the 1st century B. C. because of the decrease of the Shiyang River’s water volume. In the 2nd century A. D., some places began desertifying and from the 6th century A. D. on, the lakes began to separate into even smaller lakes. Till the time of 1840 A. D., they had all dried up and the desertification in the Minqin basin became more and more serious.

The evolution of human environment in this period was distinctively characteristic. The ways and contents of human activities essentially differed from the former period. It was mainly reflected in human being’s interference with natural environment. It can be divided into 2 stages: the 1st stage (from the Western Han Dynasty to the early Qing Dynasty) was a lightly interference period. Agricultural cultivation began with the appearance of small-area man-made oases. Although environment deteriorated in small range, the natural oasis ecosystem kept stable as a whole. There were 2 counties—Wuwei and Xuanwei—in the Minqin basin in the Western Han Dynasty with total population of 28 000. The basin at that time was a vital communication line. Because the Silk Road changed its route after the Eastern Han Dynasty, the basin then began to be in

a state of closure. Consequently, the population fluctuated at about 20 000 in almost 2000 years before the Qing Dynasty. Although small-area agricultural cultivation began from the Western Han Dynasty, the arable area was small and the farmlands were almost natural oasis ecosystems with lakes in their centers. From the Tang Dynasty, the Zhuye Marsh and the Xiutu Marsh were divided into many small lakes, but the water supply to the basin didn't decrease sharply because the population of 30 000 to 90 000 in the upper and middle reaches of the Shiyang River consumed only a small part of water. As a result, the basin's natural ecosystems, composed of lakes, aquatic vegetation and sand-fixing vegetation, kept stable.

The 2nd stage(the middle Qing Dynasty – 1950s) was a greatly interference period, which was reflected in the rapid extension of man-made oases and the natural oasis ecosystems' instability in a large scale. During the Qianlong years of the Qing Dynasty, the population in the upper and middle reaches of the Shiyang River suddenly increased to 730 000, among which 660 000 were in the middle reaches area, and accordingly, the cultivated land in the middle reaches extended to ten to tens of times as much area as that of the early times. It caused the decrease of discharge to the Minqin basin, which eventually resulted in the channel block of many rivers. Some rivers dried up, except for the time of great flood, including all the courses of the Daxi River and the Xiaoxi River, some courses of the middle-lower reaches of the Jinchuan River and some courses of the lower reaches of the Dongda River, a main branch of the Shiyang River. The water scarcity also led to gradual disappearance of most lakes in the basin. In the years of the Republic of China, most of low-lying land of dry lakes had been reclaimed except those with stagnant water. From then on, natural oasis ecosystems, which had been made up of lakes, aquatic vegetations and sand-fixing vegetation, transformed into man-made oasis ecosystems made up of cultivated land, crops and sand-fixing vegetation. Owing to the dried lakes and desertification of land surrounding the lakes, the natural oasis ecosystem become unstable.

2.3 Modern Times (1950s – Now) — Restricted Exploitation Type

Climate of this period keeps turning arid, especially shown in the increasing deterioration of hydrographic condition. Human interference with natural ecosystems became more intense, which was reflected in the disappearance of natural oases instead of the domi-

nance of man-made oases. The ecosystems of the Minqin basin were in a state of instability.

The population in the Shiyang River drainage area increased rapidly after the Liberation in 1949(Table 1). The total population increased 1.6 times in less than 30 years from 1953 to 1982. In 1988 its was 12 to 66 times of that before the Qing Dynasty and 2.7 times of that in the middle Qing Dynasty. The increasing population and the intensive exploitation of water resources resulted in serious conflict between water supply and need, as well as other problems such as ecological deterioration. Because of the lack of water, nearly 50 000ha of land in the drainage area cannot be used and nearly 30 000ha of land has to be abandoned. Because of the decrease of surface flow, over-extraction of underground water in the basin has caused great decrease in the level of underground water. In consequence, man-made and natural vegetation on the ground withered and died in a large scale, and land productivity decreased while the desertification intensified. The shrinkage of the Shiyang River drainage area gradually resulted in more area of salt-deposit land and the rise of salt amount contained in soil. The salinity in the Minqin basin also intensifies. On the other hand, over-extraction of underground water has caused the decrease of water level and the disorder of underground water's supply. The Minqin basin therefore is facing serious ecological problems (WANG Ji-he, 1995). In economical and technological aspects, the whole productive efficiency is relatively low because of the single production structure in agriculture and the low-level development in livestock husbandry. A negative system in agricultural technology is developed because of the restriction of environment. In this kind of system, the development of technology has to adapt negatively to the deterioration of the environment, rather than positively making the environment transfer to better condition. In the society aspect, the low population quality is the dominant factor that restricts the harmonizing development of man-land system in the Minqin basin.

Table 1 The change of population in the Shiyang River drainage area($\times 10^6$)

1953	1964	1982	1988	1998
1.032	1.098	1.646	1.973	2.100

3 BASIC RELATIONSHIP OF INTERACTION BETWEEN MAN AND LAND IN THE EVOLUTION OF MAN-LAND SYSTEM

The man-land system's development in the Minqin

basin originated not only from the region's inner interactions and their continuous accumulation effects, but also from outer changing power. In the view of system theory, the evolution of man-land system is the result of interactions between the system, including its elements, and the outer environment. Stimuli from outer environment include not only the evolution of a larger-scale—global or regional scale—natural environment responding to the system, but also the evolution of a large-scale human environment interrelating and interacting with the system. In a spatial perspective, the evolution of the natural environment of the Minqin basin was steady in thousands of years and the development of mankind was concordant with that of the environment. Historical remains found in this area are clearly continuous, which is proved by newly found oases and towns around the relics of ancient cities spreading in this area. In a time perspective, the interaction between human activities and the environment was an alternation of relatively stable periods and changing periods. In stable periods, the environment changed not much, natural disasters occurred less frequently, and human activities and the environment developed harmoniously. While in changing periods, the environment changed radically, natural disasters occurred frequently, and human development did not coordinate with the environment well.

The history of human society's development in fact is a history of man-land relationship's development. The extension and development of social institution, organization, culture, science, technology and tools unavoidably center the core axis of man-land relationship (CAI, 1989). Human society is the result of man-land interactions as well as the most active factor in the development of man-land relationship and the organizer and regulator of man-land system.

In the developing type of man-land dual spire and interweavement, through applying the synthetic body of land's multifunction, mankind continuously expand their living space and improve the land's bearing capacity, and eventually transfer the natural environment into human environment and human system. In this process, a rather complex feedback net is formed, in which there are two kinds of basic interaction relationship: 1) To overcome some restrictive factors by adapting and remodeling the original natural environment and primary human environment positively, and to create a man-land system more suitable for men's sustainable development. 2) Human society developing at the cost of invading the natural ecosystem and consuming resources. The basis of human existence and development is then being essentially weakened and destroyed

by rapid and burdensome population growth, unlimited extension of economy, vegetation destruction, water and land eroding, declination of land productivity, environmental pollution and ecological deterioration. Thereby a dissimilated man-land system is created, which is self-denied, and has negative effect and value.

4 MAN-LAND SYSTEM'S EVOLUTIONAL MECHANISM AND MULTIPLE DRIVING FORCES

Man-land system is a system with multiple variables composed of all kinds of natural and human elements (Fig. 2). Man-land relationship, which stems from human activities and natural environmental change in different time and space, is a sophisticated mosaic and shows common effecting factors, such as population quality and amount and the change of its consuming level, technical progress, social and economic factors, social institution and system, concept in culture and value, naturally ecological and environmental factors, combination of natural resources, and natural disaster. All these factors interrelate and affect each other, altogether forming multiple driving forces in the evolution of man-land relationship. It must be also pointed out that the composing pattern of these factors and their individual importance are different in different natural-human environment.

People's demands turn continuously from lower level to higher level. To satisfy the demands, the man-land system also develops continuously towards higher level, complication and network. Because social productivity in early civilization period was very low, especially when social organizations and ability to remold natural environment was not established, people's individual activity was limited within a small range. Therefore ancient people had to depend on and comply with the natural environment and its changes. They dwelled on flat places with well-developed network of rivers at the middle-lower reaches of rivers, were engaged in agriculture as main produce pattern and animal husbandry as the secondary. Later, when social organizations developed perfectly enough to carry out exploitation plan in organization and in steps, additionally with the improvement of social productivity, especially, the application of the technique in large-scale agriculture and the water conservancy that resulted from the improvement of production tools and the technique of irrigation works, human activities had developed from the kind of simply utilizing nature to a kind of being able to remold nature. People built dams at mountain pass to channel water, dug ditches across gravel desert and

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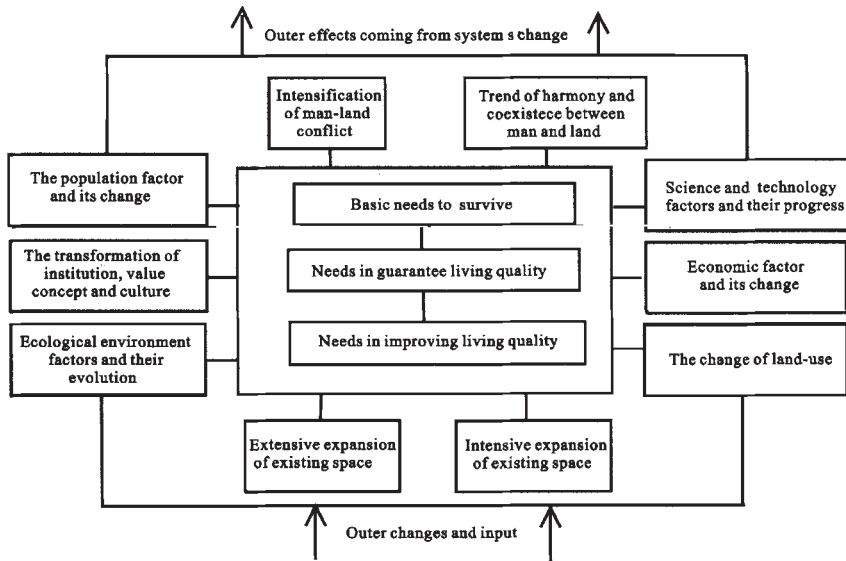


Fig. 2 Frame of evolutionary mechanism of man-land system

enlarged oases in alluvial plain. All these kinds of activities to interfere with nature succeeded in the basis of complying with the environment. The promotion of production rate due to the distribution of agricultural technique caused explosive growth of population, which made the previous oases unable to bear the newly increasing population. New land, therefore, must be cultivated and be irrigated by new reservoirs. With the social and economic development, great changes occurred in human activities' character, range and the degree, as well as in people's demands and social and economic structures (WANG Jin-feng, 1995). The relationship between human activities and the environment evolved from a type of interference to a type of restriction and exploitation. In addition, human being's living conditions worsened gradually due to the intensive human activities and a production type of pillage. Meanwhile, people's ability to recognize and resist natural disaster strengthened because of the progress of science and technology. It is evident that technological progress is the most significant and active factor to push economic progress, social change and evolution of man-land relationship. Every technological innovation strengthened the depth and range that people transformed and utilized nature, and strengthened more and more extensive and complicated relationship between man and land. Furthermore, it improved land's bearing capacity. To achieve improvement in land's carrying capacity, by means of technological advance and economic input, is the basic impetus in the development of man-land relationship. It is also the most notable character of the man-land system distinguishing from the natural system and the pure social and economic system

(WU, 1991). The fact that general development of present man-land system in oases area is in a relatively lower level determines the basis adjusting forms in regional man-land system—to stimulate, by means of inputting active and evolving elements, such as technology, capital, culture, talented persons and new concepts, and to promote the regulation of the systemic inner structure to achieve amelioration and harmony of man-land relationship.

5 EVOLUTION TREND OF THE MAN-LAND SYSTEM IN THE MINQIN BASIN AND ITS ADJUSTMENT

5.1 Evolution Trend of the Man-land System in the Minqin Basin

The patterns, intensity and consequences change continuously along with the evolution of human elements, such as social and economic structure's adjustment, technological progress and population growth, and the evolution of human environment, in addition to the evolution of the natural environment (PEARCE, 1993). The character and quantitative relationship of the inter-influence and inter-restriction between human activities and the geographic environment in the Minqin basin will be more prominent in certain future. The population will keep on growing with the growth of the society and the economy. The trend of population growth shows that the growth rate will not decrease rapidly in quite a long time. The range of human activities will keep expanding and intensifying. Especially, with the scientific and technologic progress, human ability to remold nature will be enhanced, and human activities of

politics, economy, society and culture in the basin will be more colorful. Human activities thus will be characterized with more color of purpose, more initiative and more socialization. In addition, human activities in the basin are still affected to some extent by the phenomena mentioned above. Water from the upper reaches of the Shiyang River was up to 570 million m^3 in the 1950s, while it was cut down at a rate of 10 million m^3 annually for the reasons of the increase in agricultural and industrial usage in the upper reaches and the fluctuation of precipitation in the Qilian Mountain. In the middle-later 1990s, the water volume coming to the basin was only 143 million m^3 . As far as underground water is concerned, a fact that extracting lots of water from underground exists, which is caused by the conflict between the increasing demand for water and the deficiency supply by the upper reaches. Presently, 250–300 million m^3 of underground water has been over-extracted out in the Minqin basin. The average level of stable water was kept at about 3m in the 1970s, and from then on it decreased at a rate of 0.4–0.6m per year. The level of stable underwater has averagely declined 15m until now. The over-extraction of underground water has led to a series of problems, such as the increase in mineralizing degree of underground water, abandoning cultivated land, more energy consumed in lifting water, psammophyte wilt and death, rapid declination of wind-preventing and sand-fixing systems, increasing threat from desertification and deficiency of drinking water for men and animals.

In short, the evolution of man-land system in the Minqin basin is reflected in two aspects. On one hand, the scale and strength of interference with nature will increase with scientific and technological progress and the enhancement of human ability to remold nature. Thus human activities will be more purposeful, intuitive and socializing. On the other hand, with the continual population growth and the intensification of human activities, the scale and strength, to some extent, will go beyond the environmental bearing capacity. Irrational economic activities, especially irrational utilization of water resources and destruction of vegetation, also reinforced the deterioration of previously fragile ecosystem. Considering this condition, we must try all kinds of adjusting methods to direct the man-land system in the Minqin basin to a correct way.

5.2 The Adjustment in the Man-land System of Minqin Basin—the Minqin Mode

5.2.1 To transfer traditional development strategy and

build up a concept that economic growth must harmonize with environmental quality's and land productivity's improvement

It was just the non-sustainable behaviors, which came from traditional development strategy that was decided by traditional concept, that caused so many problems in the Minqin basin, and thus threatened human being's existence and development. So it is the basis to achieve regional man-land system's sustainable development that we fundamentally transfer traditional concept and break through the regular thinking way of only developing productivity and instead form an idea that the economic development should harmonize with the improvement of environmental quality and land productivity. And this is also the premise of the adjustment in regional man-land system's sustainable development. All kinds of conflicts and beneficial distributions should be adjusted as a whole and harmonically. It can put the whole man-land system in status of circular regeneration, harmonical intergrowth and sustainable autogeny. Then the harmonization of the whole, harmonization of intergrowth and harmonization of development can be reached, and thus sustainable development can really be assured to be a reality in human's future. The more detailed strategy includes: to transfer from traditional development mode that unilaterally emphasized GNP growth as the single target to the multiple modes that not only pay attention to economic growth, social progress and environmental improvement, but also cultivate the ability of sustainable development; to transfer from high-speed population growth to population control, human resources exploitation and improvement of man's scientific and technological diathesis, which would be beneficial to the application and popularization of science and technology; to transfer decision mode made by experience to that made by science.

5.2.2 Drainage area's planning and management

Ecological environment of oasis is very fragile, in which water is the most active and sensitive natural element. After examining the evolutionary progress of the relationship among Minqin basin's environment, natural disasters and human activities, we can say that if the water status varies, a series of environmental changes will occur and human activities in this area will be restricted. Therefore, the hinge of adjusting the oasis' man-land system is to utilize water resources rationally. For this goal, uniform planning of the whole drainage area, which considers individual water system as ecological cell, should be made. The adjusting methods that water-control, salina-control and sand-control should link together and center on water-control. In the

course of planning and implementation of the resources management, drainage area should be studied as a physical and biological cell, and a social economic and social political cell as well. It is because drainage area, in ecological aspect, is integrated by the relationship among natural resources and, in social aspect, is also integrated by the ways of utilizing these resources. This character of social integration always behaves as an intergrowth relationship among various segments in the society of the drainage area. Hence it is necessary to establish an organization for managing the resources' utilization rationally and effectively. Planning of drainage area should be made well. Industrial structure should be adjusted and water and soil resources should be utilized rationally. A breakthrough from separation and provincialism should be made to allocate and manage water resources across the drainage area. The way that problems were handled separately in separate area should be changed instead of carrying out a comprehensive project of territory renovation. Certain regulations and rules should be established and all kinds of economic and political means should be applied to uniformly manage water and land resources, and the amount of water utilization should be controlled restrictedly. Study on the water resources of the whole area should be carried through to distribute water reasonably. Meanwhile, water-supervising and controlling system must be built up and optimized. And strict rules in water management should be established and carried out in the whole area.

5.2.3 Pushing forward the technique of water-saving irrigation and establishing water-saving agricultural system

To achieve the oasis' agricultural development in Minqin, various water-saving measures should be adopted, including engineering, technique and management. High-effective mode of water-saving must be especiall popularized, on the basis of experience and demonstration. Relevant examining indices should be studied out for water-saving agriculture. The ultimate goal is to set down water-using planning in agricultural area, and to popularize the techniques and methods of water saving in oasis agriculture and economy to larger scale. Detailed methods include: 1) Abandoning traditional irrigation mainly by means of flooding and massive irrigation, instead popularizing furrow irrigation and farmland irrigation; 2) popularizing the technique of crop covering and improving the efficiency of water usage; 3) popularizing the planting technique of crop's straw covering; 4) enhancing the construction of trench

system, reducing the amount of waste water and improving the efficiency of water usage; 5) introducing and popularizing some breeds of crops that consume water much less and can resist drought efficiently. In a word, synthetic research outcome should be positively used in directing the environment to a healthily developing direction. Resource-consumption should be transferred to be efficient and intensive, and be dependent more on regenerative resources. A social economy system of resource-saving should be gradually established which will consist of: an agricultural producing system that can save land, water and fertilizer; an industrial system that can save energy and materials; a transportation system that can save transporting cost; a scientific and technological system that can save capital and resources; and a social living system that consumes moderately. The economy's growth mode should be transferred from traditional mode of great investment, great consumption, severe pollution, low production and low efficiency to a mode that can save resources, decrease energy consumption, produce cleanly, improve environment's quality and add to high-tech output. Meanwhile, the principle should be emphasized that ecological and environmental protection must be in an equal position with utilization. The oasis' protection forest should be built up well to keep the balance of ecosystem and, in the end, to achieve the harmony among population, resources, environment and development.

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