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Superior coexistence: systematicALLY regulatING land subsidence BASED on set pair theory

Y. Chen[1] **and S.-L. Gong**[2]

[1]School of Foreign Languages, Tongji University, Shanghai 200092, China
[2]Center for Land Subsidence of China Geological Survey, Shanghai 200072, China

Correspondence to: S.-L. Gong (gong_shiliang@126.com)

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Abstract. Anthropogenic land subsidence is an environmental side effect of exploring and using natural resources in the process of economic development. The key points of the system for controlling land subsidence include cooperation and superior coexistence while the economy develops, exploring and using natural resources, and geological environmental safety. Using the theory and method of set pair analysis (SPA), this article anatomises the factors, effects, and transformation of land subsidence. Based on the principle of superior coexistence, this paper promotes a technical approach to the system for controlling land subsidence, in order to improve the prevention and control of geological hazards.

1 Introduction

Land subsidence is associated with the consequences of economic development and the use of groundwater and land resources, particularly in the process of industrialisation and urbanisation. It is an environmental, geological problem and an important type of geological disaster, which occurs widely in cities and urban areas. It becomes a critical factor that influences geological environmental quality, and confines regional economic and social sustainable development.

Based on the principles of mutual connection and superior coexistence in the course of economic and social development, as well as exploiting resources and ecological environmental protection, this article discusses a working plan and a technical approach for systematically regulating land subsidence using set pair analysis (SPA).

2 SPA for land subsidence

SPA is an important theory that systematically analyses mutual connections and deals with uncertainty problems (Zhao, 1996). The core of this theory is contradiction analysis to examine unity and opposites. The basic unit of contradictory unity is called a "set pair". Uncertainty exists objectively and generally in all sorts of things and systems; it is an inherent attribute and embodies movement and development. The two objects of one set pair have a relatively certain connection of contradictory unity. Differences exist in the uncertainties of transition status and incomplete information, whose process of change tends toward identity or opposite. By studying the unity, difference, contrast connection (identity or opposite), variability, and transformation of the "set pair", we can understand the rules for systematic development; furthermore, it is possible to analyse and deal with various, complex actual problems (Zhao, 2000).

Due to numerous restriction factors, as well as environmental and social influences, and a wide range of prevention and control methods, land subsidence is a complex system that contains many contradictions between the aspects of unity and system, between interconnectedness and situational changes. Uncertainty remains prevalent in the internal mechanisms, of land subsidence as well as its processes, feedback on control, and many other aspects due to the system's complexity, as well as the state of dominant and limitations. As a result, SPA could be a reference for research and prevention, and controlling land subsidence.

The essential "set pair" of land subsidence consists of the interactions between people and the land, which are interrelated and interdependent, restrict and influence each other, and constitute the system of the inner core. Land subsidence

is influenced by natural factors more closely associated with economic engineering activities such as human effects (Galloway, 2014; Gambolati, 2014). The geological environment contains natural resources on which humans rely for survival and development, and shows identity. In addition, the geological environment is the main victim of geological problems and disasters; therefore, it shows the opposite. Its mechanism, process, and form of mutual influence show difference and uncertainty; in other words, it fully embodies the characteristics of identity or the opposite.

The key to analysing land subsidence is the identical or opposite situation and influence on system characteristics. The development of land subsidence is a process of decreasing the consistency degree and increasing the antagonism degree. The actual performance is the gradual loss of resources, environmental carrying capacity, increasingly obvious latent disasters, and mutations caused by slow quantitative change. Land subsidence turns into an environmental geological problem and disaster, and then, it triggers a security crisis (Gong, 2003). Its situational changes are closely related to the rise of industrialisation, urbanisation, and development.

For example, river deltas, littoral zones, plains, inland basin areas, and other sectors with natural geographical advantages often become the centres of economic activity and urban agglomeration, where the geological environmental system is relatively weak. Regarding the background of highly intense development and utilising natural resources in geological environments, land subsidence (produced by superposing the mutual coupling of inner and outer factors) leads to land subsidence constantly progressing and being extended.

The development and use of land resources is the same as the development and use of groundwater resources, which can also lead to land subsidence. The main performance is the intensive use of land, particularly in urban areas. Since urban land resources are rare, land utilisation and three-dimensional municipal development become the inevitable choice; this makes the city expand outwardly to build up all kinds of high-level or high-rise buildings, underground space development, and utilisation on a large scale.

The permanent ground elevation loss and its subsidence difference will seriously threaten city flood prevention and security for all kinds of important projects. Land subsidence is an important part of the urban disaster system, and becomes a constraint factor affecting environmental security and sustainable economic and social development. This is an extrusive performance form of interaction between the two aspects of the "set pair" form, and causes a trend of situational change.

Ultimately, preventing and controlling land subsidence aims to keep the geological environmental system stable and secure, to make full use of underground water, land, and other natural resources, and reduce the risk of geological disasters.

3 Superior coexistence: systemic control of land subsidence

Superior coexistence includes the two aspects of the superior state and coexistence. The superior state is the safe direction of the object, and characterises the living conditions for sustainable development of the body's behaviour, and causes security to reach a more profound goal, which is development and security (Yu, 2005).

Superior state co-existence is a philosophy of safety, a new way of thinking based on the humanities and social sciences. The concept exists for purposes of natural science research, especially in terms of preventing geological hazards and controlling the engineering system, which undoubtedly leads to enlightenment and guidance. Geological disaster prevention and environmental security are also an important part of the field of non-traditional security. Superior state co-existence is a new way of thinking in terms of environmental safety to prevent and control geological disasters.

Regarding the regulation of the land subsidence system, based on SPA and superior state co-existence, in order to realise the three elements (mutual improvement and harmonious coexistence among economic and social development, the resources of development and utilisation, and ecological environmental protection) we should pay attention to the basic ideas of systemic and dialectical nature. We should also attach great importance to preventing disasters, and creating countermeasures for the dynamic integration of rigid control and flexible adjustment.

If we regard the geological environmental resource attributes as the identity of economic and social development, the degree is characterised by identity degree. We regarded the geological environmental disaster attributes as the contrariety of economic and social development. Its degree is characterised by a contrary degree. The geological environment development and utilisation attributes were regarded as the otherness of economic and social development. Its intensity is characterised by the difference degree. To ensure that the geological environment is in a safe state and cannot lead to geological disasters, we must exploit and utilise the resources effectively. In other words, that should be less than the recoverable resources and the development intensity of the disasters caused. Consequently, the geological environmental system appears in the same healthy and stable state. In addition, we can avoid or reduce the reverse state easily in order to induce geological disasters.

Preventing and controlling land subsidence requires implementing economic disaster reduction, which is synergy. Its outstanding characteristic is "negative changed into positive, changing from positive and negative to positive". Based on the influential effect of "negative" benefits caused by disaster prevention, we were able to reduce disaster losses, while reducing losses part was deemed a positive benefit. Using the dialectical standpoint of the SPA identity-diversity-oppose relation, we decreased the antagonism degree or ac-

cordingly increased the consistency degree. Therefore, we need to improve the identity of the system situation, which we called stability. The implementation of disaster prevention measures is helpful to effectively reduce uncertainty, as well as to promote an increased consistency degree and lowered antagonism degree. Comprehensive benefits obviously appeared.

As a whole, regarding the technology level of regulating and controlling the land subsidence system, how to better coordinate between urban development and environmental quality is the key content for selecting subsidence control measures and its implementation process. From the perspective of subsidence control, it is obvious that we should eliminate the various factors of subsidence. Based on the actual situation of urban development, we will obtain the greatest economic and social benefits, but consume as few resources as possible. At the same time, land subsidence also has a certain inevitability, and controlling land subsidence is the goal of subsidence prevention and control. We are allowed to have a certain amount of safety guaranteeing subsidence, on the basis of reasonable scientific allocations, and make full use of limited natural resources. This should also be the starting point to solve the dilemma of resource utilisation and environmental quality.

4 Conclusion

Land subsidence seriously restricted the social economy's sustainable development. Land subsidence prevention should emphasise economic development and resource utilisation, with the superior state co-existence of geological environment. According to academic thought and SPA, in order to comprehensively understand the unity of opposites, which contains many contradictions, and the system's uncertainty of function and influence, we must pay attention to the status, properties, and catastrophe process of the geological environmental system. We must also organically integrate long-term strategies for land subsidence prevention and treatment and practical technical measures. This will effectively promote harmony between humans and the environment, and promote security and development for humans and society.

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