

# Study on the Influence of Coal Resources Over-Exploitation on Land Resources and Countermeasures for Sustainable Development

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With the rapid development of China's national economy, the demand for coal has been increasing constantly. But the impact of coal resources over-exploitation on land resources has also attracted the people's attention, for the over-exploitation of coal resources has triggered a series of problems that threaten the sustainable development of cities. In this paper, the value composition of land resources and the influencing factors on land use value were studied in coal mining areas. Besides, based on the coupling mechanism of coal resources exploitation and land use value, in-depth analysis was conducted on their mutual influence relationship. Finally, the study of the optimal plan for coal resources exploitation and land use value was made, so as to propose one set of countermeasures for the sustainable development of land resources in the overexploited area of coal resources.

## 1. Introduction

As the main primary energy source in China, coal resources account for about 70% of China's total energy resources (Benndorf et al., 2015). The rapid development of modern industrial enterprises directly drives the mining volume in the coal market (Feng et al., 2016, Cao et al., 2016). Over-exploitation of coal, while contributing to economic and social development, can also cause significant damage to land resources in the mining area (Rao et al., 2018, Wang et al., 2017). Due to the increase of underground mined-out areas, the sharp reduction of arable land, increase of employment pressure on farmers and social unrest factors will inevitably cause serious consequences for ecological destruction, social economy and urban construction, and then affect the harmonious development of local people and nature in coal mining areas (Obersteiner et al., 2016, Abdulrahman & IR, 2014). Land resources in coal mining areas are important carriers of people's material base and production data (Shi et al., 2012).

With the continuous exploitation of coal resources, the utilization of land resources has been affected (Fürst et al., 2013). The protection of agricultural land is becoming more and more urgent. In recent years, due to the increase of the demand for land resources and the serious shortage of land resources, our country is facing a severe situation of land resource utilization (Xu et al., 2018). In order to solve the contradiction between Chinese mineral resources (coal etc.) development and land resources, it is necessary to comprehensively study the land use value in coal mining areas and establish a series of measures to control land subsidence. Besides, more attentions should be paid to the protection, development and reuse of land resources after mining (Zhao & Y., 2013, Li et al., 2017). This paper breaks through the shackles of the traditional use of land resources and provides reference and guidance for the use and protection of land resources in large areas of coal resource exploitation areas. It is of great significance to ensure the quick and harmonious development of social economy.

## 2. Value composition of land resources and its influencing factors in coal mining areas

### 2.1 Value composition of land resources in coal mining areas

The value of land resources in coal mining areas includes: ecological value, social value, and economic value

of land. Fig.1 shows the value composition of land resources in coal mining areas. The social value of land in coal mining areas is mainly composed of social stability value and social security value. The economic value of land resources is the capitalization of the use of land by landowners to obtain rent. The ecological value of land in coal mining areas is the value embodied in various functions of the land ecosystem. The classification and content of ecosystem service functions are shown in Table 1.

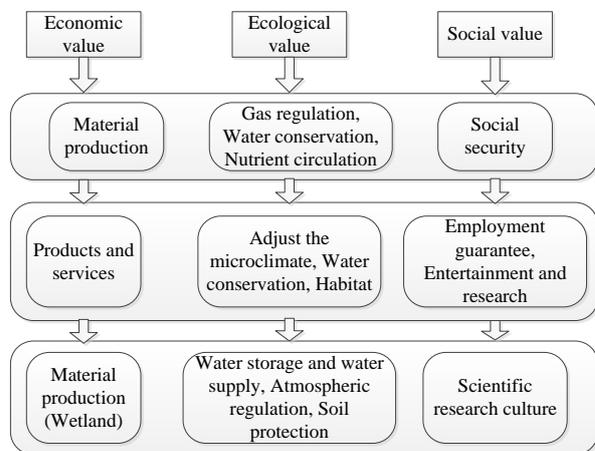


Figure 1: Value composition of Coal mining area land resources

Table 1: Types and contents of ecosystem service functions

Number	Types of ecological services	
1	Supply function	Raw material, Water supply, genetic resources
2	Regulating function	Disturbance regulation, Atmospheric regulation, Water regulation
3	Support function	Soil formation, Biological control

## 2.2 Influencing factors on land resources value in coal mining areas

The influencing factors on the value of land resources in coal mining areas can be divided into social-economic environment factor and natural environment factor according to the relationship between the influencing factors and the land in coal mining areas and the scope of impact. Normally, coal mining has a negative impact on the land value of the mining area, esp. producing a greater impact on the value of damaged land. The market supply and demand, regional economic conditions, and demographic factor play major roles in the socio-economic environment factors. In general, the more developed for the region, the higher the average level of its land value. The higher quality of population indicates the higher average technical level of the society, and then the land in the coal mining area can realize the intensive use so as to increase the value of the land in the coal mining area. With the increase in population, the demand for land will increase; according to the principle of market supply and demand balance, the land value will be correspondingly rise. Topography, natural disasters, and environmental quality in natural environment factors have a significant impact on the value of land in coal mining areas. The land with a flat terrain and good geological condition is relatively high in land value. Natural disasters will cause surface subsidence and damage to the surface buildings, which will increase the cost of land development and utilization in the coal mining area, thus greatly reducing land value.

## 3. Coupling relationship between coal resource exploitations and land resources value

### 3.1 Analysis for the impact of coal resources recovery rate on land value

Different mining methods of coal resources have different impacts on land resources. In this paper, the impact of coal recovery rate on the value of land resources was mainly discussed. Fig.2 shows the change law of land use value under different recovery rates. It can be seen from the figure that the recovery rate affects the amount of land subsidence; the lower recovery rate at the lower degree of land collapse means higher use value of land resources. Fig.3 shows the coupling mechanism between coal mine value and land use value. The coal mining and land resources have the relationship of mutual influence and mutual restraint in the process of mutual use. Based on the above analysis, they can be connected by coupling relationship. When exploiting at 80% of recoverable reserves, the coupling relationship between coal mining value and land use

value is shown in Fig.4.

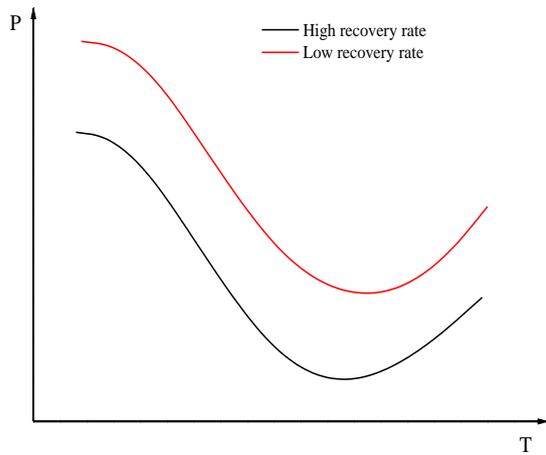


Figure 2: The rule of land use value with different extraction ratio

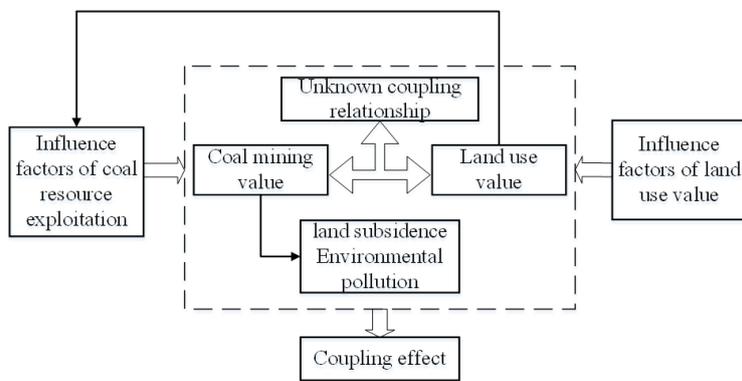


Figure 3: The coupling mechanism of coal mining value and land use value

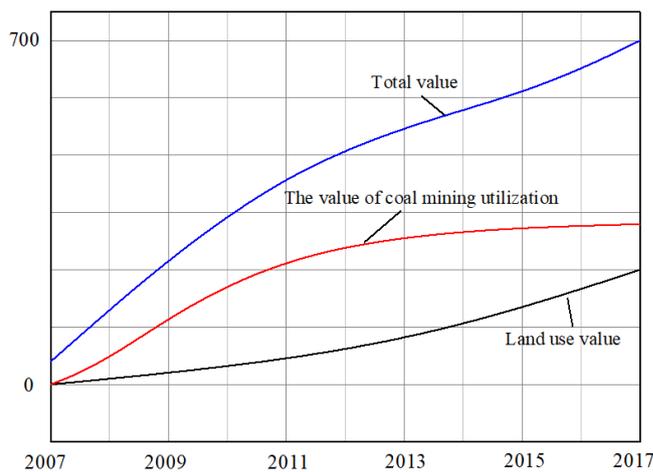


Figure 4: The coupling relationship between coal mining value and land use value when mining rate is 80%

### 3.2 Impact of overexploitation of coal resources on land resources

With the rapid economic development, the demand for coal in China has increased, and the coal mining has shown a large-scale rise. Fig.5 shows the changes in coal production from 2008 to 2017. Due to the high coal prices and the higher profitability of coal, coal enterprises, especially private enterprises, are basically

producing in full capacity or even over-producing, under the constraints of safety production supervision. This will inevitably cause over-exploitation of coal resources., which will affect the use of land resources and lead to more damage to the environment and land, e.g., the coal gangue hill will be under pressure and open-pit mining will directly destroy the surface. Extraction and drainage during mining will result in water-diverting fractures, destroying groundwater resources and indirectly affecting the value of land resources. Over-exploitation of coal in mountain mining areas will cause land subsidence, underground cracks, or funnel-shaped sinkholes. In the low-water-drainage mining area, over-exploitation of coal resources will cause annual accumulation of water in a small part of the area, and water-soil loss and salinization will easily occur in the water-logged areas. In high-drainage plain mining areas, the overexploitation of coal resources will result in the destruction of local water conservancy facilities and the cessation of farmland production. The problem of land subsidence caused by over-exploitation of coal resources will lead to the aforementioned serious consequences.

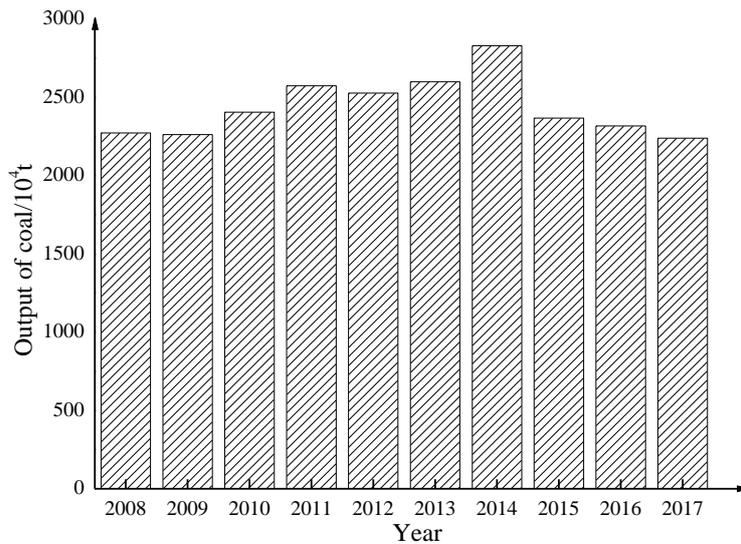


Figure 5: Coal production change in Xuzhou from 2008 to 2017

#### 4. Study on the sustainable development of land resources in coal mining areas

##### 4.1 Determination of the optimal plan for the coal resources mining and land use value

In the coupling relationship between the coal resources mining value and land resources value, the main influencing factor is the recovery rate of coal resources. With other variables constant and different recovery rate as  $a$ , analysis was conducted to determine the optimal plan for coal resource exploitation and land use value. When the land of coal mining area is urban construction land or historical and cultural protection land with great demand for economic value and social value, the sum of the two kinds of value coupling relationships was denoted as  $T$ , and the maximum value of land resources use as  $N$ . Without the coal resources exploitation, i.e., the recovery rate  $A = 0$ , the coal resources cannot be effectively used, and then the coal resources value  $C = 0$ , so  $T = N$ . Fig.6 shows the curve between land resources use value and coal resources mining value. When the coal resources are fully mined, i.e.,  $A=100\%$ , the coal resource value is  $M$ , the land resource value before mining is  $N$ , and the land resource use value is  $D$ , to obtain  $T=M+D$ . Because of the different relationship between  $T$  and  $N$ , there exist two situations:

- 1) At  $T \geq N$  and  $T_{\text{optimal}} = T_{\text{max}}$ , the curve of land use value and coal resource mining value are shown in Fig.7. It can be seen that land use value is lower and it is located in a poor area. The coal mine is of good quality and has high mining value. Comprehensive analysis indicates that coal mining can be carried on.
- 2) At  $T \leq N$  and  $T_{\text{optimal}} = T_{\text{max}}$ , the curve of land resource use value and coal resource mining value is shown in Fig.8. It can be seen that the land use value is large, the mining value of coal resources is small, and the comprehensive analysis indicates protecting the land resources, and stopping coal resources mining.

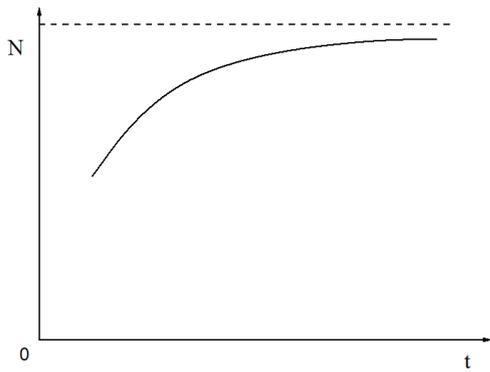


Figure 6: The curve of land use value when  $A$  is 0

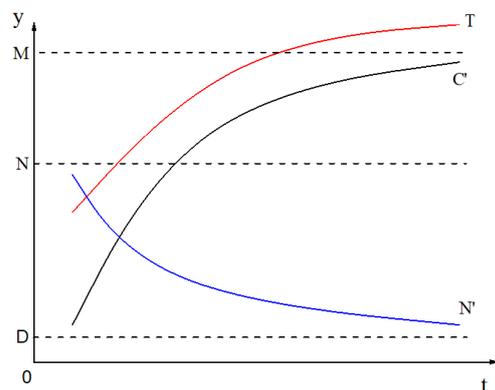


Figure 7: The curve of value when  $a$  is 100% and  $T > N$

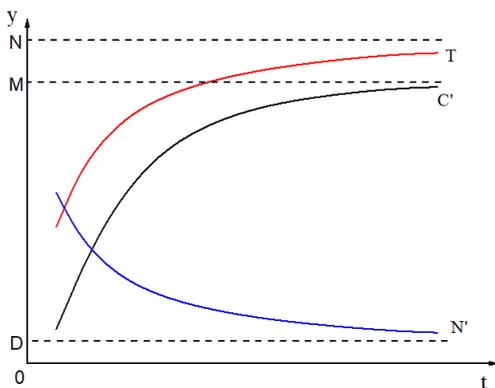


Figure 8: The curve of value when  $a$  is 100% and  $T < N$

#### 4.2 Proposal for sustainable development of land resources in coal mining areas

In overexploited areas of coal resources, all behaviours of pollution and destruction of land resources should be prohibited, and the protection of land resources in coal mining areas should be strengthened. For coal mining areas located within the city, during the coal mining, it must not only consider the economic benefits of coal resources, but also require more for the social functions of the land resources in this area. Damage to land resources should be avoided as much as possible during the mining process. The exploitation of coal resources should give way to the protection of land resources in order to promote the efficient and healthy development of the local economy. For townships with a small population and remote coal mining areas, in the exploitation, it's necessary to avoid destroying the local ecological value and maintain the sustainable development of the ecological environment. In case of the destruction of land resources due to the excessive

exploitation of coal, the relevant coal enterprises must promptly make up for the destruction of land resources and take the initiative to take responsibility for environmental protection.

## 5. Conclusions

This paper studies the impact of coal overexploitation on the land resources, and then proposes the countermeasures for sustainable development of land resources in coal mining areas. The specific conclusions are as follows:

The value composition and influencing factors of land resources in coal mining areas were studied and analysed, to conclude that the land resources use value should consist of ecological value, economic value and social value.

Combining the deep connotation and connection between the coal resource mining value and land resource use value, the coupling relationship between them was established by analysing their value composition, and thus the optimal plan  $T_{max}$  of coal mining and land resource use value was obtained.

According to the actual situation of coal resources exploitation, through the comprehensive analysis of the land resource use value, ecological environment, and population density in the mining area, one set of countermeasures applicable to the sustainable development of land resources in the coal mining area was proposed.

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