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## Article

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# The “Classification - Strategies” method for the eco-transition of “mine-city” system-taking Xuzhou city as an example

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## ABSTRACT

The transition of coal-exhausted city (CEC) has been a worldwide problem, the transition planning of the CEC is a synergetic procedure. When we look into the transition problem of a larger CEC, the difficulties for the city planner come from the synchronicity, otherness and complexity of the “Mine-City” system. Xuzhou City is the largest CEC in the world and has the most complex “Mine-City system”. The researches on the transition of Xuzhou would be a good example to the complex “Mine-City” system planning in the world. The bio-city is the best transition target for Xuzhou city. Based on this understanding, a “Classification-Strategy” method for Xuzhou city's eco-transition is proposed. The “Mine-City” system of Xuzhou is classified into 3 basic types: urban type, rural type and suburban type. The corresponding practical strategies are proposed. The “Classification-Strategy” method has the advantages of simple and practical, and can give the city planner a more comprehensive consideration of the planning elements during the eco-transition of the “Mine-City” system.

## 1. A worldwide problem: transition of “Mine-City system”

The transition of “Mine-City system” has been a worldwide problem. According to the data of the American mining association, there are about 80 thousand to 250 thousand abandoned mines in the United States.<sup>1</sup> In Ruhr, which has 100 years of coal mining history, the number of coal mine decreased from 141 in 1957 to 3 in 2015, and Germany will close all their coalmines in 2018 (Li Leilei, 2002). In Asia, China is the top coal consumer in the world. There are totally about 10,760 coalmines in China, and 5600 of them will eventually be closed under a policy of resource and environment protection, according to the estimation of the China National Coal Association.<sup>2</sup> Therefore, China's resource-exhausted cities need transformation and development.

During the development of a mine or a mine-group, a village nearby usually would be built up for the worker's family living. With the extension of the mining period, the village may grow into a city. This is the so-called “Mine-City system”(Chen & Qian, 2006). However, once the mine is resource-exhausted and going to be closed, the “Mine-City system” will face with the problem of transition. This kind of city is defined as the Coal-Exhausted City (CEC) (Qian Yong, 2007; Zhang Yicheng, 2006).

In fact, the “Mine-City” is a complex system with complexity characteristics. CEC are built due to mines, booming with mines, and declining with mines. As resources become increasingly depleted, a series of urban, environmental, and ecological issues arise. How to plan the transition of the CEC has got a wide attention in the world (HansPeterNoll, Gernot Pahlen, 2007).

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<sup>1</sup> Data sources: Data statistics of the American mine association in 2017.

<sup>2</sup> Coal mine safety net. Coal Association: the elimination of small coal mines to production capacity is limited on the exit mechanism of state-owned enterprises[EB/OL]. <http://www.mkaq.org/html/2015/07/14/311315.shtml>, 2015-07-14.

Affected by foreign studies and the development characteristics of mining areas in China, overseas research on the transformation of CEC shows two trends: on the one hand, from the perspective of industrial transformation and sustainable economic development (Marsh B, 1987), research on the industrial structure of CEC has changed from a single to diversified still prevails. On the other hand, the research starts from the sustainable development of resource-exhausted cities (Gill A.M, 1990), combine the reuse of mining areas with urban ecological environment governance (Corona Joel, 2004) and social problem solving. The research involves ecological reconstruction of mining areas, ecological space reconstruction of CEC, and sustainable landscape design (Klaus Beckmann, Inken Tintermann, 2004), the methods of the CEC transformation are widely used on abroad. However, the related theories and practices for transformation of CEC are scarce in China. Therefore, the research hope to analyze the cities and mining areas, explain the planning strategy of mine city collaborative ecological transformation in Xuzhou.

Xuzhou City is the largest CEC in the world and has the most complex “Mine-City system”. The researches on the transition of Xuzhou city would be a good example to the complex “Mine-City” system planning in the world. In this sense, the authors take Xuzhou city as the research background and worked out a serial of practical transition planning methods to the “Mine-City” systems in this paper.

## 2. “Mine-City” system of Xuzhou

Xuzhou city is located in the northwest of Jiangsu province. Its total area is 11,258 square kilometers and urban area is 3037 square kilometers. There are 5 municipal districts, 3 counties and 2 county-level cities in this city. The total population of Xuzhou is 8.71million (Jiang Xin, 2011).

Coal mining was one of the pillar industries of this city. There is a coal mining history of more than 120 years in Xuzhou. The highest annual coal mining output was about 25 million tons. Coal mining brought considerable economic benefit to Xuzhou in the history.

However, with the exhaustion of coal resources, land subsidence, village relocation, cropland decrease, abandoned infrastructure (traffic and water conservancy etc.), environmental degradation and other issues are also increasingly prominent in this city.

When we look into the “Mine-City” system of Xuzhou with a systematic point of view, a typical characteristic is that there are both synchronicity and otherness between the mine and city in a whole system (Li Zhijiang, Ma Xiaodong, 2011). This characteristic leads to more complexities in the city's transition planning.

### 2.1. The synchronicity between the mine industry and the city

Differing from common cities, a prominent of the CEC is the synchronicity between the mining industry and the city during their development and transition, even though sometimes they are two independent systems in the same geographical area.

In the initial stage, with the developing and maturing of the mining industry, the economic output of the resource-based city rises rapidly (Wang Bang-jun, Zhou Min, Ji Feng., 2009); The development of mining industry provides conditions for the rising of the resource-based industrial chain in the city; Community of the mining enterprise leads to the rapid development of construction of all kinds of urban infrastructures in the city (Warren R. L, 1963); With the development of the city, the external resources and supports to the mining area are improved. Taking the advantages of the city's buildup effect and innovation system, the location disadvantage of the mining area can be partially overcome then; After many years' mining, inner connections in almost every social aspect between the mining area and the city have been set up.

In this sense, it can be concluded that, not only in the developing stage but also in the resource-exhausted stage, there is the synchronicity between the mine and city in Xuzhou.

### 2.2. The otherness between the mine industry and the city

In a CEC, it's undeniable that the city and mining area are two relatively independent systems with different interest and demands. They are prone to be divergent or even uncooperative in some cases.

It's stated that since there are the similar interests in the economic construction and environmental governance, the government (represents the city) and mining enterprise (represents the mining industry) inclined to cooperate and get positive results in the transition in these aspects. On the contrary, in those aspects of residents' living, municipal construction, labor and social security, culture and education, health, etc., because of the lacks of same interests, the government and mining enterprise often worked as independent systems with different responsibilities. The development in those aspects falls behind then.

### 2.3. The complexity of the “Mine-City” system of Xuzhou

When we talking about the transition of a CEC, particularly a large CEC such as Xuzhou, one difficulty comes from the complexity of the “Mine-City” system.

The synchronicity of the “Mine-City” system requires the government gives a comprehensively consideration both on the mining area and the city, and make out a mutual-beneficial transition plan. Then, the question is how to integrate the spatial structure of the mining area into the optimization of the overall urban and rural functional structure.

The otherness of the “Mine-City” system requires the government makes out a ‘Discrepancy-Based Design’, considering the different demands and characteristics of mining area and the city. Then, the question is how to keep the equilibrium between the mining

area and the city in landscape planning, industry/commercial transition, eco-environment governance, social problems solution and sustainable development.

Besides these contradictory requirements, more factors should be taken into consideration during the planning for CEC's transition, such as:

- (1) The transition target of a bio-city<sup>3</sup>
- (2) The temporal and spatial evolution attribute of the mining area and their influence on the evolution of the spatial structure of the CEC.
- (3) The database for monitoring and evaluating the society elements of a CEC, particularly the resource of different mining areas and their integration potentialities and effects into a whole macro city system.
- (4) The law/regulation system based on the vision of the resident and the government to drive the transition of the CEC
- (5) The balance strategies among the society elements in a “Mine-city” system, including economy, culture, residence, education, transportation, landscape, environment, etc.

### 3. The “Classification-Strategy” method for CEC transition planning

Since the mining area and the city has been a complex symbiotic system, the transition planning of the CEC must be a synergetic procedure. For a better operation of this, the authors propose a “Classification-Strategy” method for Xuzhou city's CEC transition planning. The following steps are included in this method:

- (1) Determination of the transition goal of a CEC;
- (2) Construction of the synergism operation model including varied planning elements during the transition of a CEC;
- (3) Multi-factor Classification of the “Mine-City” system in a CEC;
- (4) Formulation of corresponding planning strategies for different “Mine-City” system types based on the synergism operation model in step (2).

The primary advantage of this method is its simple and practical operation for city planning in a complex CEC system. Secondly, this method gives the city planner a more comprehensive consideration of the planning elements during the synergetic transition of the “Mine-City” system.

### 4. The target and synergism operation model of the transition planning of Xuzhou city

#### 4.1. The transition target of Xuzhou

There is a rich connotation in the concept of bio-city, which gives a more comprehensive target system to a bigger CEC, says Xuzhou. Bio-city means not only a city built from the principles of ecology to eliminate all carbon waste (zero-carbon city) and to merge the city harmoniously with the natural environment but also a city with a sustainable economy, smarter city life, comfortable transportation, improving health, etc (Wang Bang-jun, Zhou Min, Ji Feng, 2009). Many modern concepts for future city have been included in this concept, such as smart City etc.

In addition, this target is compatible to the national development strategy of China. The “Yangtze-Huaihe ecological corridor” is one of the most important development plans in the eastern part of China. The construction of the Yangtze-Huaihe ecological corridor is a major practice for docking the Yangtze River Economic Belt and the Huaihe River Ecological Economic Belt, and exploring the sustainable development of the basin (Hong Huimin, 2014). Xuzhou is the key city in the north branch of this plan. If the bio-city can be taken as the transition target of Xuzhou, it's easier for Xuzhou to get the support from the central government.

Once the transition target has been determined, in the following sections, the term Eco-Transition will be employed in the transition planning of Xuzhou.

#### 4.2. The synergism-planning model of the eco-transition of Xuzhou city

A synergism model is necessary for the eco-transition planning with a more comprehensive consideration on those planning elements involving economy, society, resources, environment, policies and regulations and so on (Li Wei, Sun Dongping, Lu Xin, 2010). This model, as shown in Fig. 1, is established according to the connotation of bio-city, the complexity CEC system and the laws of ecological transition to expound the mutual influence and organic relation among the elements in the urban ecological transformation in Xuzhou.

There are 4 subsystems (decision system, evaluation system, planning system and the targeting system) are included in the model. According to their functions, these 4 subsystems are classified into 3 dimensions: Dynamic dimension, Method dimension and Effect dimension. 5 series of policy/regulation are listed in the aspect of “dynamic dimension”. Driven by these policies/regulations, 5 series

<sup>3</sup> Wang Bang-jun, Zhou Min, Ji Feng, Analyzing on the selecting behavior of mining cities' industrial transition based on the viewpoint of sustainable development: a perspective of evolutionary game[J]. Procedia Earth and Planetary Science, 2009(1):1647.

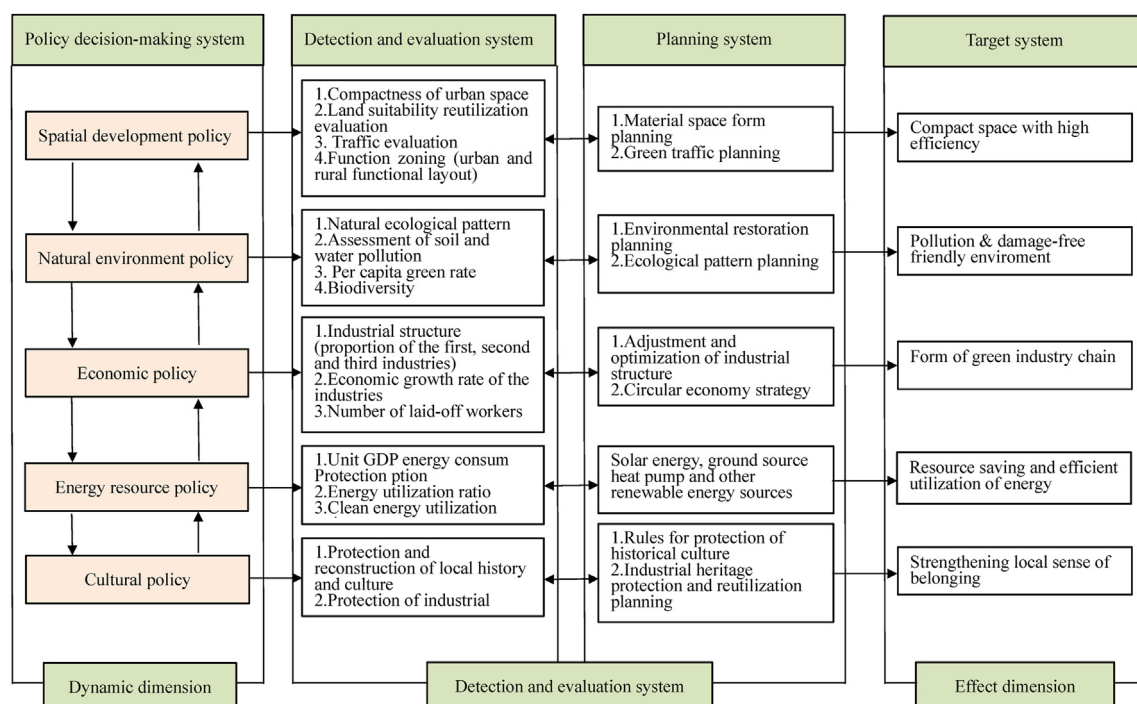


Fig. 1. The synergism-planning model of the eco-transition of Xuzhou.

of planning elements are shown relatively in the method dimension and the effect dimension.

When we look into the 5 series in the “dynamic dimension”, it can be seen that besides the application of new energy and cultural policies to all mining areas, the other three policies have higher requirements for the location and surrounding environment in the mining area. Therefore, this paper extracts the factors of location, economy and traffic as the main factors for the classification of the “Mine-City” system in Xuzhou city.

#### 4.3. Classification of the “Mine-City system” of Xuzhou

There are totally about 33 coalmines in Xuzhou city. Most of the coalmines distribute in the east and west of Xuzhou city. A small number of the coalmines are located in the north of the city. Although the coalmines in our study range are relatively concentrated, their effects on the city are quite different because of their different traffic conditions, surroundings and status (Yuan Zuhua, Zhou Min, 2012).

The analysis in this stage is no longer confined to coalmines and their effect to the city, but also the surrounding factors and the interactions between city and mine are comprehensively considered. As pointed in the former sections that the most important single factors are location, traffic and economy, the classification on the “Mine City” system starts from this.

In the view of urban development, the location factor is a key factor to determine the relationship between coalmines and cities. It also determines the traffic and surrounding environment of the coal mines, and then affects the regional economy. Therefore, the location factor is the most important factor in the pattern division of coal mine in the urban area of Xuzhou city.

In this sense, the authors classify the 33 coalmines within Xuzhou City or the study area into 3 types. They are: Urban-type, Rural-

Table 1

Classifications of “Mining – City system” of Xuzhou.

| Ming area · City Link content         | Urban-type mining area-Urban cooperative type | Rural type mining area-City Cooperative type | Suburb type mining area-City Cooperative type |
|---------------------------------------|---|--|---|
| “Ming area city” Degree of dependency | Marginal zone of the city center              | Rural area                                   | Marginal zone of the city                     |
| Industrial structure                  | Second and third industry oriented            | First industry oriented                      | First and second industry oriented            |
| Environment                           | Evolution into the village in city            | Affect basic farmland                        | Affect the expansion of urban space           |
| Land value                            | Value of commercial development               | Production value and ecological value        | Industrial value and ecological value         |
| Social instability factors            | Laid-off workers                              | Land-lost farmers                            | Land-lost farmers and laid-off workers        |
| Representative coalmines              | 5 coalmines                                   | 12 coalmines                                 | 16 coalmines                                  |

type and suburban-type of “Mine-City” system. In the following sections, many strategies are designed in view of the former classification. The main characteristics of each type of “Mine-City” system have been listed in [Table 1](#).

## 5. Eco-transition strategies for urban type “Mine-City” system

### 5.1. Strategy 1: Cultural niche and its cultural force

#### 5.1.1. Concept of cultural niche

Cultural Niche means that one or more cultural characteristics can interact within the same area, thereby playing its/their cultural advantages that are unique to the area (Nicole Creanza, Laurel Fogarty, Marcus W. Feldman., 2012). Therefore, urban-type mining areas and their surroundings “architectonic features of the built environment tend to make them part of the city's cultural heritage and form a valuable niche”, we shall carry out industrial heritage culture and regional culture cooperative development with the construction of cultural niche ([Leng Yanju, 2011](#)).

#### 5.1.2. Construction of cultural niche in urban-type “Mine-City” system

In urban type mining areas, there could be many decayed or even abandoned industrial construction remains near the city blocks ([Wang Xianfeng, 2003](#)). In addition, there are many poor educated populations in this area. Considering its special character, it's not proper to introduce any industry into this area for ecological consideration. The cultural niche is a good choice in this situation.

The core idea of this strategy is to awake the awareness of urban heritage culture, and increase the sense of belonging of the local residents. There are many practical manners to fulfill the cultural niche:

- (1) Construction of university district (or educational district) based on the renovation of the industrial construction heritage. In China, with the expansion of the cities, many universities or colleges need to move from the central area of the city to a further place. In a CEC, urban type mine area is a rather good choice for these universities because of the cheap land price and the rich industrial culture. For the mine area, once a campus district constructed there, not only the economy but also the cultural quality of the residents in the “Mine-City system” will be improved in this cultural niche.
- (2) Construction of Creative Industrial or Multi-culture Park ([Zhang Sheng, 2010](#)). With the rise of urbanization, creative industries are booming in China. In a CEC like Xuzhou, it will promote the industrial upgrading and improve the professional quality of employees in the Urban-type coalmine area through this plan.
- (3) Construction of the Counterpart Research Institutions. There are many urban industries in the fringe. Most of them have the desire to build their own R&D centers and research institutions. In this case, it is a good opportunity to construct counterpart research institutions according to the characteristics of the urban industries in the urban type mine area.

Effective cultural force can be explored from the development of education, culture and technology to promote the eco-transition of the “Urban-type Mine-City system”. There are many examples in the world that the construction of the University City or the support of the scientific research institutions has successfully promoted the eco-transition of a city. Through the construction of multiple cultural niche, the city's social and cultural system will be upgraded and the industrial heritages in the mine area be revived.

### 5.2. Strategy 2: geothermal center based on abandoned underground mining space

#### 5.2.1. Renewable resources in resource-exhausted cities

The reason why so many resource-exhausted cities in the world are suffering from resource depletion can be attributed to too much dependence on the non-renewable resources (such as various types of mining). In fact, if the inherent renewable resources of a CEC can be explored timely, the city will rejuvenate soon. The success of this eco-transition mode relies on the re-exploration of the renewable resources in a CEC ([Zhang Wei, Zhang Wenxin, Cai Anning, Liang Jinshe, Lu Guowei, 2013](#)).

In “urban type Mine-City system”, there would be many residential or commercial areas near the mine area. The geothermal energy in the abandoned underground coalmine tunnels can be extract out in this case and the industrial workshop on the ground can be Constructed into Geothermal Center to supply thermal or refrigeration service to its around city area. The coalmine populations in the urban type mine area can be gradually transferred into new energy population then.

#### 5.2.2. Geothermal based eco-transition strategy of “urban type Mine-City system”

The temperature in the deep ground is relatively stable throughout the years. It is lower than the surface air temperature in summer, but higher than the surface air temperature in winter. Taking this advantage, we can Construct the abandoned coalmine roadway into a huge heat exchanger to absorb the thermal energy with the ground.

Water is a good working fluid for this purpose. In winter, the warm water from the underground roadway can be pumped up onto the ground, and then exchange its heat to a central or distributed heat pump system to supply heat to around district. The water exhausted its heat will be pumped back to the underground roadway again to absorb the heat from the ground; During summer, the cold water is pumped out from the roadway and then exchange its heat with a central or distributed refrigerator to supply air-conditioning service to its around district ([Mohammad Amin Mirzaei, Ahmad Sadeghi Yazdankhah, Behnam Mohammadi-Ivatloo, Mousa Marzband, Miadreza Shafie-khah, João P.S. Catalão, 2019](#)). Through the utilization of geothermal energy, The COP (Coefficient of Performance) of both the heat pump and the refrigerator in this system will be much higher than that in air-source heat



pump or refrigerators systems. Much energy can be saved then.

In addition to the heat exchanger, the underground roadway can also be rebuilt into a heat accumulator. In this case, the underground roadway is employed as a seasonal thermal accumulator. In winter, the cold water or ice slurry from the surface water (say, lakes or rivers) is pump into the shallower roadway underground and stored there. In summer, cold water stored in the shallow roadway can be pumped out as the direct cold-source for the air-conditioning in the living area. The used water (temperature increased) from the living area can be transferred back to the shallow roadway again and exchange its heat with the cold underground rock. After the stored cold water is used up, the roadway works in heat exchanger mode.

In winter, the working procedure of the system is similar to that in summer. There are 3 main differences between them: (1) The hot water must be stored in the deeper roadway to take the advance of the higher ground temperature there; (2) The hot water for seasonal heat storage comes from the solar collector in summer or the waste industrial heat source in the mining area.

Detailed engineering discussion of this plan can be found in reference.

The Corresponding Reward Policy for the new-energy's utilization is a key point in this plan. Firstly, the land developers should be encouraged to unite the coal mining enterprises and the relevant science and technology departments to carry out the development and utilization of underground excavations; Secondly, there should be a principle of “benefiting the investment” to the earnings from the new energy regenerated from the roadways; Thirdly, the government should give a certain policy and financial support to those new energy projects with larger early investment. This is favorable to the eco-transition of the mining area and the city.

## 6. Eco-transition strategies for “rural type Mine-City system”

In this section, 3 target-oriented eco-transition strategies are proposed based on the characteristics of “rural type Mine-City”.

### 6.1. Strategy 1: Regeneration of the mining area through “enclave” industrial pattern

“Laying eggs in the nest of others” is a good choice to active the eco-transition of “Mine-City system”. Here the “nest” is the original industrial land, infrastructure and industrial buildings in the rural type-mining areas. This type of mining areas is far from the urban built-up areas, and it is difficult to introduce projects into these mining areas due to their poor position conditions, even though, there are many idle lands in this area. At the same time, the original industrial land and relatively perfect infrastructure of this type of mining area will be soon abandoned due to the coming closure of the mine. Therefore, the incorporation of the rural type mining area land into the urban land use system, and regarding the land as an “enclave” of the city (Zhang Jinsuo, Kang Kai, 2009). The introduction of the “enclave” economic development model will not only reduce the leasing cost of project development and construction, but also achieve the city project establishment demand, and bring new economic development vitality to the development of the mining area losing the support to activate the secondary development vitality of the economy in the mining area.

For the mining areas, villages and cities, the “enclave” economy is like an optimal “configurator”. It can be optimally allocated with this concept the city's capital, technology, management advantages, rural low labor cost and ecological environment resources and the land resource, complete industrial infrastructure and technical personnel. New pattern of complementary advantages and coordinated development could form with this strategy (Fig. 2).

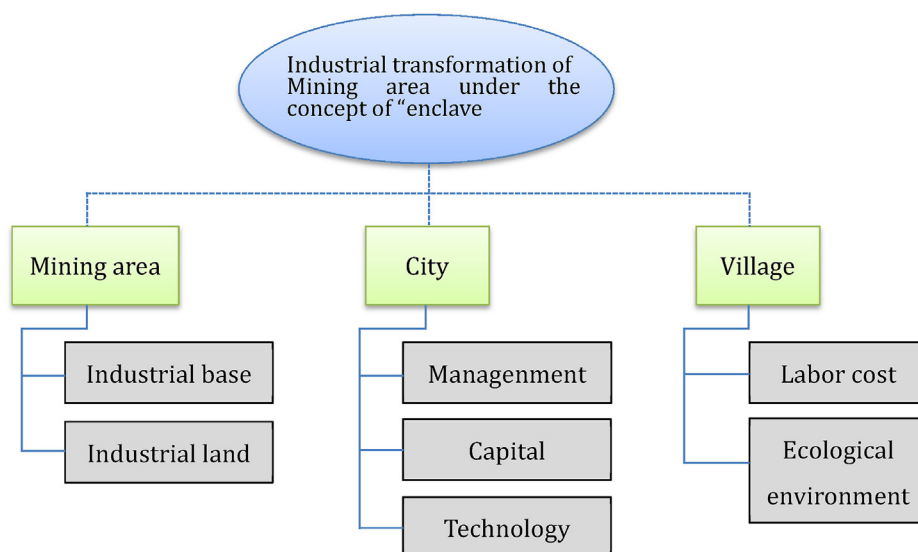


Fig. 2. Analysis of rural tape mining industry transformation with “enclave” concept.

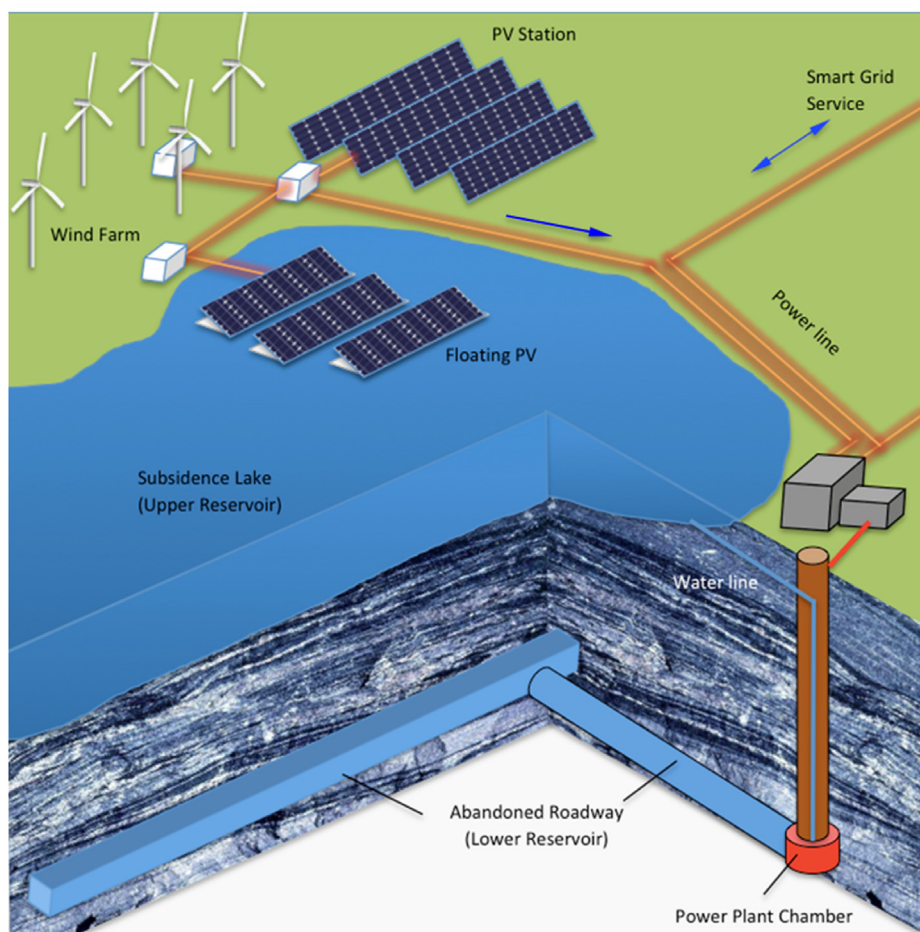


Fig. 3. Abandoned coalmine employed as pump-storage station.

## 6.2. Strategy 2: new energy center based on pump-storage with abandoned coalmine

One hard task in the rural type mining area is the restoration of the subsidence mining slash (Luo Pingjia, Chen Ning, 2011). There is a comparatively abundant water resource in Xuzhou area. In most cases, the subsidence pits are filled with water. A multi-lake landform is the usual appearance in the rural mine slash and the surface is divided into many small plots by these subsidence lakes then. This makes it difficult to restore the land into farm, nor to introduce modern commercial or industry into these areas.

On the other hand, Xuzhou is a traditional energy city in eastern China. Depending on its coal resource, the coal-fired power industry has been booming for decades of years. Now the energy industry in Xuzhou is asked to transit from the tradition energy to new energy. The largest crystalline silicon factory in Asia has been located in this city. The government of Xuzhou is planning to build up a 1000 MW PV power station in its northeast rural area. The urban wind power generation is also under construction in this city.

Combining the former conditions, the authors propose a new energy center strategy based on pump-storage with abandoned coalmine. The operation of the system is shown in (Fig. 3).

Underground coal mining is the main mining method in Xuzhou. There are hundreds kilometers of abandoned roadway left underground in the rural area of the city. The abandoned roadway can be rebuilt into huge waterproof tank and used as an underground lower reservoir. The subsidence lake on the ground is rebuilt into upper reservoir then. There is a several hundred meters height difference between the upper reservoir and lower reservoir. Taking the advantage of the potential energy between the two reservoirs, an underground pump storage station can be built up.

The large area of the surface slash land (or water surface) can be used for PV station in this strategy. Wind power is another optional plan but more conditions are required. However, one prominent defect of solar power or wind power comes from its volatility. Particularly when there is a large installed capacity of those new energy powers, it will lead to disastrous impact to the operation of grid. The underground pump storage station is a good solution to this. When the power output from the new energy station is over the grid's need, the excessive power can be used for pumping the water from lower reservoir to the upper reservoir. While the power need from the grid is more than the output of the new energy station, the water can flow back from the upper reservoir to the underground roadway to drive a hydraulic turbine for power output.



There is a high flexibility in this strategy. The pump-storage station is installed underground and has very limited influence on the landscape on the surface. The surface land can be planned for new energy power station, wetland park, nature ecological recovering, farm land, etc. Even if the surface is planned for solar power station, the layout of the PV array can also be flexibly amounted according to the requirement of agriculture and solar complementation or geodetic landscape.

Besides the former benefits to the urban coalmine area, there are still many contributions of this strategy to the eco-transition of Xuzhou city, even the eastern China:

- (1) Once the problem of large-scale energy storage is solved, the new energy capacity will increase greatly in this city. The photovoltaic industry chain will effectively be boosted by the consumption of PV product in Xuzhou.
- (2) Based on (1), there is the potentiality that Xuzhou, as a CEC, may lead to practical smart grid technology. Industries related to smart grid technology will also be driven up because of this.
- (3) The traditional energy population in Xuzhou city will then transit to new energy population, based on (1)(2).
- (4) The resource of the pump storage with abandoned coalmine in Xuzhou can be employed to support the coast nuclear power (poor load adjustment) industry or for the offshore wind power industry in eastern China. Jiuli Lake Ecological Wetland Park is the largest urban ecological wetland park in the country and one of the ecological wetland parks built by coal mining subsidence in the country.

### 6.3. Strategy 3: Countryside economy driven by the mining area

There is a serious disturbance from the rural type coalmine to the utilization of the land, the living environment of the villagers and the economic situation in the rural area during the mining process and the stage of subsidence. Considering this influence from the mining procedure on the regional ecological system, it is suggested a synergistic development strategy of both this type of coalmine and the rural area (Luo, Lu, & Ren, 2011).

The land resources should be re-planned according to the nature of the land in cooperating with the transition of the rural mining area to meet the local farming, forestry, construction land and so on. Water logs and swales which are unsuitable for re-construction can be re-built up to landscapes such as the sightseeing lake and wetland as an ecological setting of the transition of the mining area to realize the cooperative development of the economy and the ecology of the rural type mining area.

On the other hand, the pillar role of the mining area in the regional economy must be taken into consideration. While the exhausting of the coal resources, other industries related to the mining must be encouraged, including the industries such as the coal chemistry, coal electricity, integral gasification electricity, slime power generation, building materials, etc., to achieve a smooth transformation and sustainable development of the mining area economy (Xu Xiangzuo, 2013). On this basis, the allocation of agricultural resources in the rural area can also be synergistically transferred to increase its ecological value and tourism value. As to the problems during the transition of the system such as the less compensation to the occupation of the villagers' land, it is suggested to protect the villager's right with a stronger social security system of the government.

## 7. Eco-transition strategies for suburban type “Mine-City” system

The suburban-type mining area is located in the transitional area between the rural and urban areas. It has certain development foundation in economic and social level, but still differs from that in the city space or rural space. While planning the development mode in this type of area, the planner should integrate the development advantages, optimize existing industrial legacy, develop the intensive industry and make full use or recycle of the industrial facilities left in this type of mining area to fulfill an eco-transition based on ecological restoration. Considering the specialty of this type of mining area, the author names the suburban-type mining area as the Third Space of the synergistic transition of the “Mine-City system”.

### 7.1. Strategy 1: Innovation of the urban Third Space

#### 7.1.1. Concept of the urban Third Space

Because the regional environment of the suburban mining area is different from the urban and traditional rural areas, it has an excessive spatial feature in economy and population, so it is defined as the urban Third Space (Fig. 4). Different from the transition strategy of the urban-type mining area and rural-type mining area, the transition strategy of the urban synergy Third Space has the group space attributes of relatively independent in the new industrial park with complete functions and the development ability of radiating to the surroundings.

#### 7.1.2. The eco-transition strategy of the Third Space

The eco-transition strategy of the Third Space includes the overall transition planning of the ecological restoration, industrial development, residence and other aspects of the mining area (Soja Edward W, 1996). The overall transition of the mining area is not only the unilateral transition of various fields, but also the overall organization of the mining area.

During the transition to the urban synergy Third Space, the ecological restoration of the subsidence area is very important. This will make subsidence land change from a pollution sources in the suburbs to an important ecological corridor, in which the rural ecological space transfers to the urban ecological space. With this opportunity, it is possible to develop a suburban ecological park and integer the ecological transformation of the subsided land and the development of the services in the mining area to achieve the

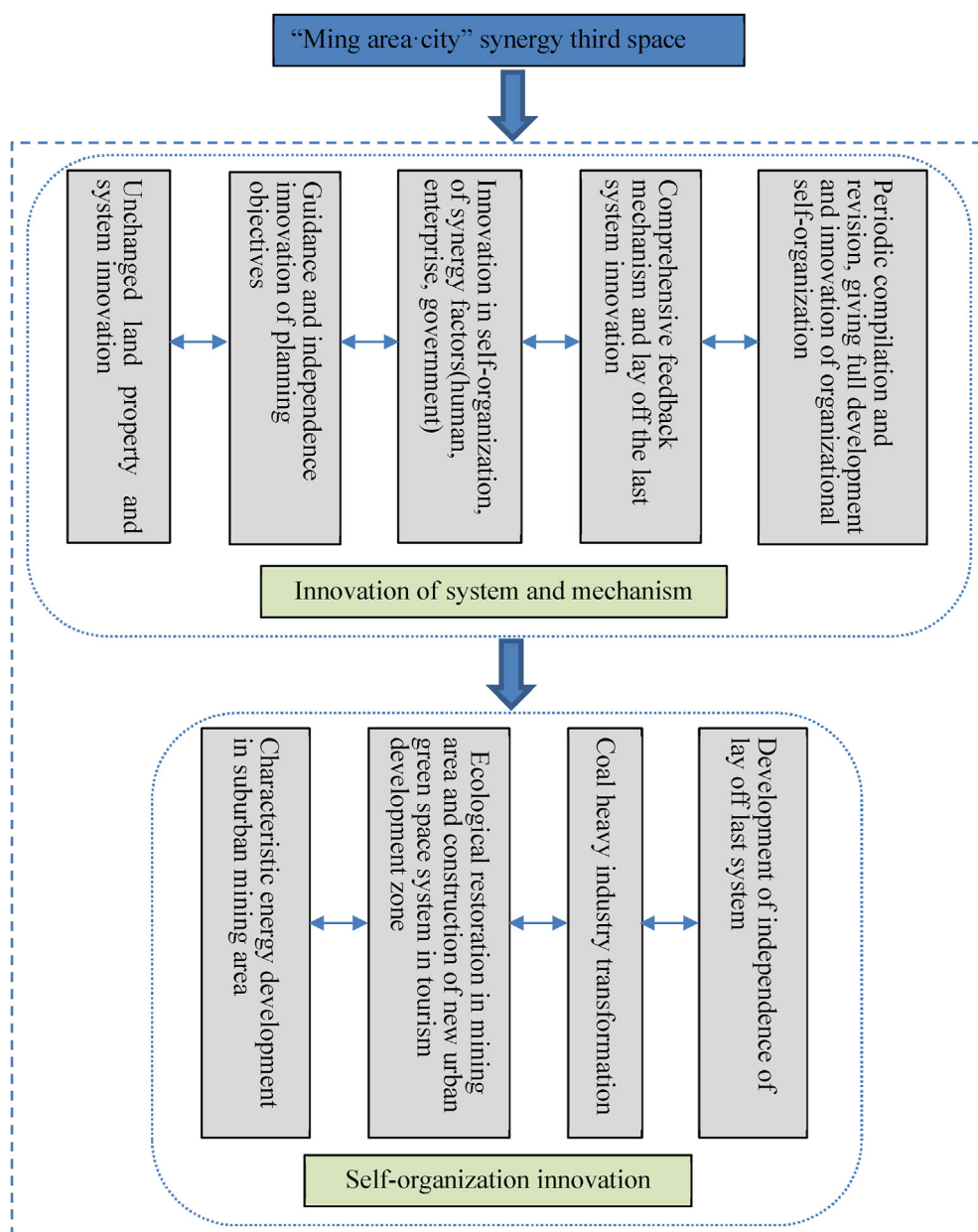


Fig. 4. The frame of the development of Third Space.

ecological and economic co-promotion.

The following factors must be considered during the innovation of urban Third Space: unchangeable land property and innovation in system; innovation in the guidance and independence of the planning objectives; the self-organization of the collaborative elements (the people, enterprises and government) and the integrated feedback mechanism; regular compilation and revision, and full development and innovation of the self-organization of the organizations (Mu Dong; Du Zhiping, 2000). The self-organization innovation in the synergy Third Space mainly embodies in the characteristic energy development in the suburban mining area, the ecological restoration and the tourism zone development in the mining area, the construction of the green space system of new towns, the transformation of the coal heavy industry and the new independent development with a “lay-off- the-last” system.

In the establishment of the urban synergy Third Space, the following planning principles should be paid enough attention to:

- (1) More centralized planning should be made to the suburban type of mining area.
- (2) Suburban mining area must pay more attention to the overall coordination between the regional and urban area, and actively integrate itself into the city's industrial upgrading and eco-transition.

- (3) In the process of economic transformation, the designers should pay attention to play their own advantages of different mining areas, and make the plan or design according to the principle of local conditions.

## 7.2. Strategy 2: Industrial structure optimization and promotion on new intensive industries

The basic idea of this strategy is to construct the industry chain to realize the transition and sustainable development in the suburban mining areas, including:

- The transition from coal industries to the non-coal industries;
- The transition from the pollution industries to the ecological industries;
- The transition from the single industries to diversified industries;
- The transition from exhausted industries to sustainable industries.

In view of the actual situation of Xuzhou suburban mining area, the author believes that the industrial chain model of “industry continuity + superseding industry + regional urban-rural integration” can be adopted. Coal mining industry is the middle input-based industry, and the industrial extension model extends the industrial chain forward and backward by using this feature (Zhang Mi'er, 2002). The advantage lies in that it can give full play to the advantage of local resources, namely the advantage of coal resources in the transition period, and change the former linear economy development mode featured by “resources - products - wastes - pollution emissions” unidirectional flow to the circular economy development mode featured by the “resources - products - renewable resources - products” (Fig. 5).

The development of coalmines generally goes through the following steps: increasing of mining quantity - smooth mining quantity-decline in mining quantity - closure, which is the inevitable fate of the common mining-area. For the suburban type mining areas of Xuzhou, if hope to break this destiny, high-tech industries, modern agriculture, tourism, logistics and trade industry must be developed simultaneously. During the urban planning and layout, the suburban mining areas of Xuzhou should focuses on the implanting of new industries and re-constructing of bio-city, with the goal of building an economic region with increasingly close economic ties between town and county. The integrity of the economic development must be strengthened, that is, to develop to the integrated urban and rural economy, and improve the cooperative economic network.

## Conclusion

The transition of the coal-exhausted city (CEC) is a realistic proposition in city planning research in the world (Hong Huimin, 2014). Considering the complexity of a larger “Mine-City” system planning, a “Classification-Strategy” method has been developed. The primary advantage of this method is its simple and practical operation for city planning in a complex CEC system.

The following concludes can be drawn while Xuzhou is taken as the example to show the operation of the “Classification-Strategy” method in a complex “Mine-City” system:

- (1) Bio-city is the best transition target for Xuzhou city. To fulfill this target, a synergism-planning model of the eco-transition is necessary to be developed, Explore the city's potential and realize the transformation from a resource-exhausted city to an eco-city.
- (2) Mine located in various areas of the city have their own different regional characteristics, traffic characteristics and economic characteristics, The “Mine-City” system of Xuzhou can be classified into 3 basic types: urban type, rural type and suburban type.
- (3) As to the urban type “Mine-City” system in Xuzhou, 2 eco-transition strategies are proposed: Cultural Niche and its cultural force, upgrade the urban heritage culture, increasing the sense of belonging to local residents; Geothermal center based on abandoned underground mining space, provide ground cooling, heating demand, the formation of peri-urban energy “base.”.
- (4) As to the rural type “Mine-City” system in Xuzhou, 3 eco-transition strategies are proposed: Regeneration of the mining area through “enclave” industrial pattern, promote the coordinated development of the mining, urban and rural areas, and improve the development quality of surrounding villages; New energy center based on pump-storage with abandoned coalmine; Countryside economy driven by the mining area, Improve the quality of the ecological environment around rural mining areas and integrate it into the urban landscape ecosystem, so that the transformed environmental landscape can still become the urban ecological base. Bring certain economic value to the mining area and surrounding villages.
- (5) As to the suburban type “Mine-City” system in Xuzhou, 2 eco-transition strategies are proposed: Innovation of the urban Third Space, reuse of subsidence land on the basis of ecological restoration; Industrial structure optimization and promotion on new intensive industries, principles of industrial transformation from “single” to “multiple”, from “decentralized” to “integrated”.

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resources - products" (Fig.5).

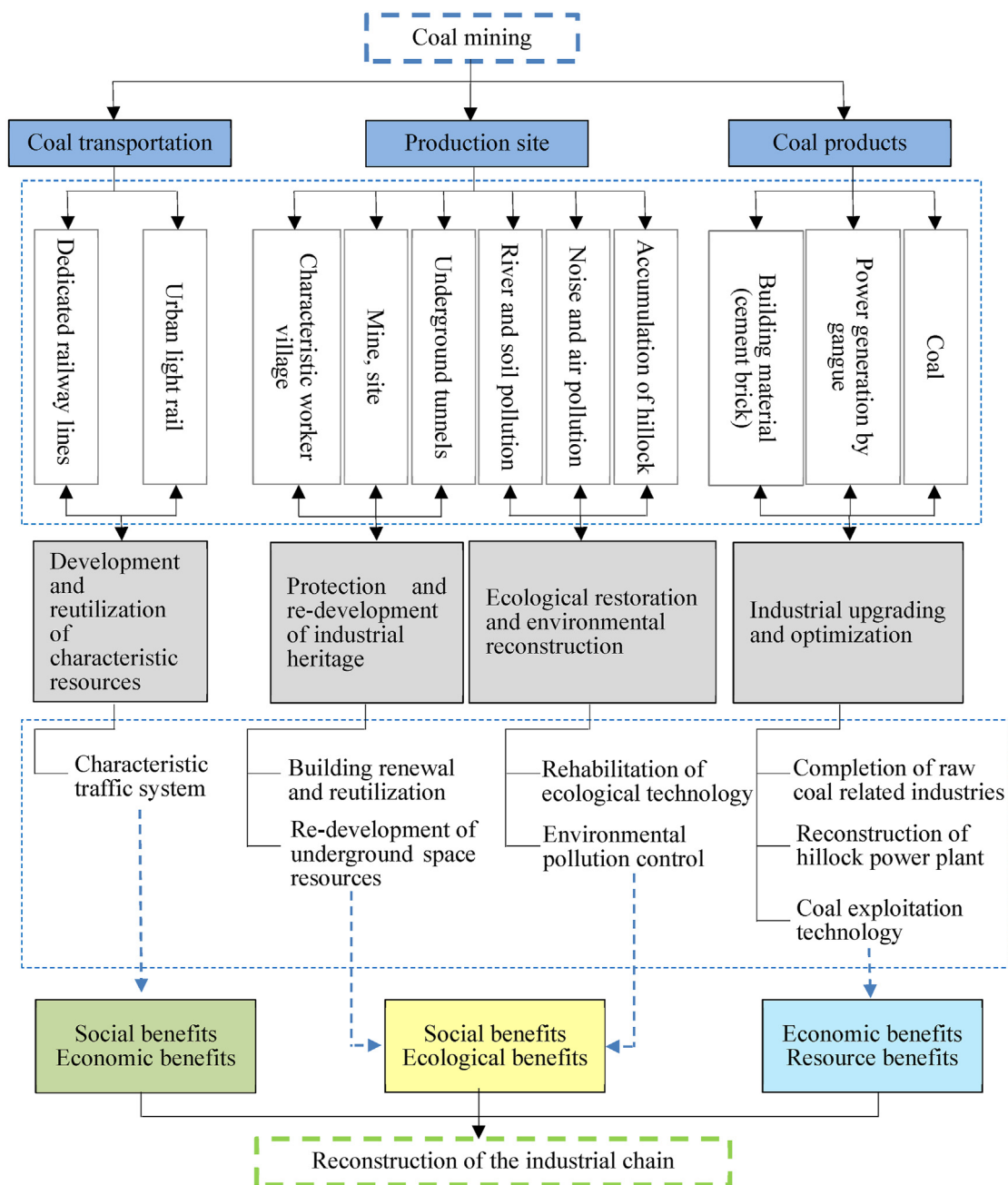


Fig. 5. Industrial chain optimization in Dahuangshan coalmine.

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## References

- Leilei, Li (2002). Reverse industrialization and industrial heritage tourism development: Practice process and development model in Ruhr area, Germany. *World Geographic Research*, (3), 57–65 2002.
- Chen, Y., & Qian, Y. (2006). Co-evolution of resource-based enterprises and cities in China. *Industrial Technology and Economy*, (1), 66–70.
- Corona, J. (2004). *Essays in Brownfield Redevelopment*, Doctoral dissertation. "Are Brownfield Externalities Capitalized into Surrounding Housing Prices"[D]University of Connecticut 2004.
- Dong, M., & Du, Z. (2000). *Self-organization theory analysis of the evolution process of the mining city coupling system*[D]. Doctoral Thesis of Chinese Academy of Sciences.
- Gill, A. M. (1990). Enhancing social interaction in new resource towns: Planning perspectives [J]. *Journal of Economic and Social Geography (TESG)*, 81(5), 348–363

- 1990.
- HansPeterNoll, G. P. (2007). Brownfield Redevelopment in the Ruhr [J]. *Urban Planning International*, 2007, 36 03.
- Hong, H. (2014). Establishing an ecological economy corridor around Huai River to promote the coordinated development in central and eastern China[J]. *Economic Affairs*, 2014(4).
- Jiang, X. (2011). On the development of modern coal in Xuzhou [J]. *Journal of China University of Mining & Technology (Social Science Edition)*, 2011(5).
- Li, Z., & Ma, X. (2011). Study on spatial expansion of resource-based cities-taking Xuzhou city as an example [J]. *Territory & Natural Resources Study*, 2011 03.
- Li, W., Sun, D., & Lu, X. (2010). Coordination analysis and evaluation in planning environmental impact assessment [J]. *Journal of Arid Land Resources & Environment*, 2010, 4.
- Luo, P., Lu, W., & Ren, L. (2011). Landscape ecology based mining area subsided land Reutilization planning and design method-with Jiuliqu mining subsided land as an example. *Chinese Garden*, 27(6), 96–100.
- Luo, P., & Ning, C. (2011). Abandoned coal mine tunnels: Future heating/power supply centers[J]. *International Journal of Mining Science and Technology*, 21(5), 637–640 2011.
- Marsh, B. (1987). Continuity and decline in the anthracite towns of Pennsylvania [J]. *Annals of the Association of American Geographers*, 77(3), 337–352 1987.
- Mirzaei, M. A., Yazdankhah, A. S., Mohammadi-Ivatloo, B., Marzband, M., Shafie-khah, M., & Catalão, J. P. S. (2019). Stochastic network-constrained co-optimization of energy and reserve products in renewable energy integrated power and gas networks with energy storage system[J]. *Journal of Cleaner Production*, 223, 747–758.
- Qian, Y. (2007). Definition of resource-exhausted cities and its policy implications: A case study of Liaoning province[J]. *Journal of Liaoning Technical University*, (6), 585–587 (Social Science Edition).
- Soja Edward, W. (1996). *Third Space: Journeys to Los Angeles and Other Real-and-Imagined Place*. Oxford: Blackwell4–6.
- Wang, X. (2003). “Niche” type urban development: research on urbanization roads in backward areas-taking Zhangjiajie in Hunan Province as an example [D]. Beijing: Graduate School of Chinese Academy of Social Sciences 2003.
- Wang, B.-jun, Zhou, M., & Feng, J.i (2009). Analyzing on the selecting behavior of mining cities’ industrial transition based on the viewpoint of sustainable development: A perspective of evolutionary game[J]. *Procedia Earth and Planetary Science*, 2009(1), 1647.
- Warren, R. L. (1963). *The Community in America [M]*. Chicago: Rand McNally College Publishing.
- Xu, X. (2013). Main practices and Revelation of industrial transformation in Ruhr mining area of Germany [J]. *Coal Economic Research*, 33(5), 74–77 2013.
- Yanju, L. (2011). Culture thoughts on the transformation of resource-exhausted cities [J]. *Urban Development Research*, 2011(5), 108–111.
- Yuan, Z., & Zhou, M. (2012). Collaborative development mechanism research on mines in transformation in resource - based city —with Huainan city as an example [J]. *Academics*, 2012(3), 218–229.
- Zhang, Mi'er (2002). *Research on the Industrial Transition of the Resource-based Cities [D]*. Dalian University of Technology.
- Zhang, Y. (2006). *Analysis of Resource-Exhausted Cities, Philosophy of Geosciences and Building a Harmonious Society*. Beijing: China Dadi Press.
- Zhang, S. (2010). Key points of EIA of the old industrial zone: A case study of Xinzha industrial park, Zhonglou economic development zone, changzhou, Jiangsu [J]. *Environmental Science and Management*, 7 2010.
- Zhang, J., & Kang, K. (2009). *Regional Economics [M]*. Tianjin University Press 2009.
- Zhang, W., Zhang, W., Cai, A., Liang, J., & Lu, G. (2013). Relationship between coal mining subsidence and urban development in coal cities: A case study of tangshan city [J]. *China Land Science*, 27(12), 73–79 2013.