Effects of Soil Organic construction on Regional Surface ET and GPP of Coal mine goaf

Li Gang¹, 2, 3, 4, *, Lu Nan¹, 2, 3, 4, a, Wang Na¹, 2, 3, 4, b, Wei Yang¹, 2, 3, 4, c

¹Shaanxi Provincial Land Engineering Construction Group Co., Ltd.
²Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd.
³Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources.
⁴Shaanxi Provincial Land Consolidation Engineering Technology Research Center.

*Corresponding author e-mail: 454923994@qq.com, ¹854933189@qq.com,
b41370199046@qq.com, c276387126@qq.com

Abstract. Based on the status of coal mine goaf restoration and the theory of organic land reorganization, we take the coal mine goaf in Yulin, northern Shaanxi as an example, and how does the development of organic soil reconstruction technology affect the surface ET and ecosystem GPP. Aiming at the problems such as soil pollution and ecological environment degradation in the mined-out area of coal mines, this study uses the integrated technology of land engineering and takes "process-mechanism-test-demonstration" as the main line to carry out targeted "differential remediation" and implement it accurately. System integration, research and development of soil organic reorganization and vegetation reconstruction technology systems in coal mine goafs, respectively, to promote cross-cutting research in areas such as land engineering, restoration ecology, ecological hydrology, etc. The research on the impact of the process on regional ET and GPP has scientific guidance significance for scientifically carrying out land reclamation in coal mined-out areas, regulating land use methods, mitigating and adapting to climate change, and improving the ecological environment.

1. Introduction

As the world’s largest carbon source, in addition to directly emitting huge amounts of greenhouse gases into the atmosphere, coal mining also affects the amount of greenhouse gases in the air through land use and land cover change (LUCC). Coal mining activities have not only caused changes in overlying strata, but also formed huge coal mine goafs, causing problems such as subsidence, soil pollution, and ecological damage (Zhang et al., 2019). At the same time, it will also cause changes in surface plants and soil texture, which will affect the ecosystem around the mining area. Comprehensive management of the mined-out area is generally considered a world problem (Fang glory, 2018).

Some domestic research and engineering practices have shown that land remediation is an effective technology for pollution and damage to land. It has irreplaceable effects on ecological environment
protection, food security, and urban-rural integrated development. "Community of Life" ecological concept and effective measures of China's "Thirteenth Five-Year Plan" ecological environmental protection plan. As the main engineering method of land remediation practice, land engineering is the process of using engineering methods to turn unused land into usable land or use the used land for efficient use, and to coordinate the harmonious development of human-land relations. Land engineering can reasonably allocate land resources and organize land use, from the macro to the micro, from the global to the local, and maintain a more reasonable land use structure to obtain the maximum functional benefits (Han Changchang, 2017). The core of land engineering lies in the improvement of land quality, the reconstruction of the soil structure, and the transformation of the soil environment quality. The purpose is to make the soil meet the needs of the participation of organic life, which is the theory of soil organic reconstruction. The theory takes a certain depth of soil as the research object, and conducts research around the materials and structures that make up the soil. It uses replacement, compounding, and addition and reduction techniques to overcome defects such as degradation, pollution, damage, and inefficiency. Soil or unutilized soil is used for regeneration or reconstruction to reshape the soil into a soil that can support life characteristics and realize the survival and reproduction of living bodies (Han Changchang, 2013). It is the land remediation, utilization and protection of China in the new era. The new connotation and new direction also provide theoretical guidance for related land improvement projects.

Compared with the traditional coal mine goaf management technology, land engineering integration technology can construct a new mine reclamation soil structure, which can effectively improve land reclamation through soil leveling, cultivation layer construction, and biological nutrition protection engineering. Stability and sustainability; can also accelerate the rate of natural restoration and soil quality evolution, through soil physical regulation, section level reconstruction, biological reconstruction, biological nutrition guarantee and other means to eliminate land waste, Ecological problems such as soil pollution and soil instability. The application of the theory and technology of soil organic reconstruction can not only greatly shorten the period of treatment and repair of polluted and damaged soil, improve the efficiency of treatment, accelerate the speed of ecological restoration, but also save engineering costs and reduce ecological and environmental risks. The theory and technology of organic soil reorganization are the basic ways to realize the management of damaged soil.

As one of the important ways to change land use / land cover change (LUCC), the use of soil organic reconstruction technology to carry out land reclamation and ecological restoration in coal mines' goafs has significantly changed the land surface biogeophysical processes (surface Albedo, roughness, hydrothermal processes, etc.) and biogeochemical processes (carbon absorption, emissions, etc.) will have a profound impact on regional and global climate (Liu Jiyuan et al., 2011; Lee et al., 2011; Devaraju et al., 2015; Lai et al., 2016; Arneth et al., 2017; Deng et al., 2017; Li et al., 2017a). Therefore, the application of soil organic reconstruction technology can be used as an important driving factor for regional climate and ecological environment changes, especially in large-scale carbon source areas such as mine goafs. The effects of environment and climate change are more significant (Shao Yan & Zeng Xiaodong, 2012; Lawrence et al., 2010; Brovkin et al., 2013; Zhang et al., 2014; Malyshev et al., 2015). Assessing the impact strength and characteristics of soil organic restructuring technology on regional climate and ecosystems, one of the important methods of LUCC, is one of the core contents in the field of climate change and ecological environment research (Liu Jiyuan et al., 2015; Devaraju et al., 2015; Lawrence et al., 2016; Deng et al., 2017).

2. ET and GPP in Land surface process
Evapotranspiration (ET) and total primary productivity of the ecosystem (GPP) are two key variables in terrestrial biogeophysics and biogeochemical processes. ET connects the material and energy exchange processes such as surface energy, water, and ecosystem carbon cycle, and is one of the core processes of climate change and ecosystem response research (Cheng et al., 2017; Sun et al., 2017). GPP is the total organic carbon fixed by the vegetation to absorb CO2 in the atmosphere through
photosynthesis. It determines the initial materials and energy entering the ecosystem and plays a very important pivotal role in the carbon cycle of the atmosphere and ecosystem (Beer et al., 2010; Jung et al., 2017). Changes in land cover caused by large-scale human activities (urbanization, deforestation, afforestation, etc.) will inevitably affect terrestrial ET and GPP, and then affect regional/global climate and ecosystems (Wang Yuanyuan et al., 2015; Lawrence et al., 2010; Liu et al., 2012; Sterling et al., 2012; Yan et al., 2014; Devaraju et al., 2015; Krause et al., 2017). Quantitatively reveal the impact intensity and characteristics of soil organic reconstruction technology on ET and GPP, which is one of the important methods of LUCC. Not only is one of the important contents of regional ecological environment governance research, but it is also very important for the study of human land use regulation and control in response to climate change.

3. Status of the study Area

Yulin is the most important coal base in our province. It has a decisive position in Shaanxi. It is a rare high-end energy and chemical base on the Belt and Road. It has rich coal resources, huge potential and obvious advantages. 54% of the city’s land area contains coal. The proven reserves are 150 billion tons, and the predicted reserves are 280 billion tons. The development of coal in the region started in the 1980s. At that time, most of the mining was small mines. There were a series of problems such as low resource recovery and utilization, and poor safety and reliability. After more than 20 years of development, Surface subsidence, falling groundwater levels, geological hazards, and damage to the ecological environment have become important issues that plague local people's lives, businesses, and the safe and sustainable development of Yulin. Therefore, for the comprehensive management of the ecological environment in the region, it is necessary to establish the four-in-one land remediation concept of “quantity, quality, ecology, and humanity”. Based on the principle of “sustainable development” of the ecological environment, comprehensive ecological management of the mined-out area of the coal mine is carried out. The governance of the mined-out areas of coal mines must adhere to the two aspects of ensuring food supply security and ecological environment security, and achieving the simultaneous development of human settlement environment, production environment and ecological environment in the region. The comprehensive ecological management of coal mine goafs is a necessary means to achieve land and ecological security, and it is a guarantee to solve the contradiction between the supply and demand of natural resources and achieve the harmonious development of human-land relations. Through comprehensive management and reconstruction of coal mine goafs, this fragile ecological environment can be promoted. It is necessary to carry out systematic investigation and research on soil pollution and ecological environment of the mined-out area of coal mines, as well as research on soil organic reconstruction and vegetation reconstruction techniques.

It is foreseeable that the large-scale land reclamation and ecological reconstruction process in the region by means of organic soil reconstruction technology will, to a certain extent, cause great changes in the surface coverage and soil structure in the region. The activities caused typical activities of large-scale and rapid changes in ground cover. This drastic LUCC process will significantly affect the climate change and ecological environment in the region. Under this background, scientifically quantifying the impact strength and characteristics of organic restructuring of soil on ET and GPP and its characteristics for the northern Shaanxi coal mine goaf and even the same type globally Regional ecological environment governance is necessary.

4. Research method

The impact of human interference on regional ET and GPP is mainly reflected in large-scale large-scale large-area research. The main research method is to rely on 3S technology to conduct simulation research. Due to the complexity of the relationship between LUCC and natural land surface processes, it is difficult to obtain high-precision data such as LUCC, ET, and GPP. It is still difficult to quantitatively and accurately estimate the intensity and characteristics of the impact of LUCC on ET and GPP (Liu Jiyuan et al., 2011; Pielke et al., 2011; Deng et al., 2013). The current fast-growing
new-generation land-surface process model (LSM) containing carbon and nitrogen biogeochemical processes of terrestrial ecosystems more fully describes the complex nonlinear relationship between LUCC and land-surface processes. In order to quantify the difference between LUCC and natural factors, the impact of ET and GPP offers the possibility (Wang Yuanyuan et al., 2015; Liu et al., 2012; Sterling et al., 2012; Yan et al., 2014; Yang et al., 2015). However, the inadequacy of the LUCC parameterization model of the model, the uncertainty of the parameters and the input data of the LUCC and the meteorology led to the uncertainty of the model simulation of the impact of the LUCC on the land surface carbon and water flux (Chen Guangsheng & Tian Hanqin, 2007; Lawrence et al., 2007; Bonan et al., 2011; Chen et al., 2011; Li & Arora, 2012; Ménard et al., 2015; Schultz et al., 2016; Madhusoodhanan et al., 2017; Chen et al., 2018). At present, research on the impact of LUCC on land surface ET and GPP urgently needs to improve the LSM subgrid LUCC parameterization scheme, optimize the key parameters of the model ET and photosynthesis processes, and develop high-resolution and high-resolution input data such as LUCC, meteorology, and soil properties.

As a typical region where strong human activities affect the natural environment on the land surface, the research on the impact of coal mining on regional climate and ecosystems in the Yulin area of northern Shaanxi has received more and more attention this year. Most scholars mainly use regional climate models and hydrological models to simulate study the impact of coal mining on climate and ecological environment changes in the region. However, there are limited studies on the quantitative and systemic effects of land reclamation and vegetation reconstruction in the region on regional ET and GPP and ecological environment changes.

Based on the above research background and current situation, we raise the scientific questions of this project: Taking the coal mine goaf in the Yulin area of northern Shaanxi as an example, what impact will the development of organic soil reconstruction technology have on surface ET and ecosystem GPP? How to use field measurements and model simulations to reveal the intensity and characteristics of this impact and its impact on the future climate and ecological environment in the region? In response to scientific issues, we have formulated the following main research contents: Firstly, based on our previous surveys and surveys of 7 coal mine goafs: Kaiyuan Coal Mine (39°16′6″N, 110°9′54″E), ground service coal mine (39°16′3″N, 110°9′49″E), Kokolai Coal Mine (39°26′54″N, 110°7′53″E), Masonry Coal Mine (39°15′29″N, 110°9′45″E), Shijietai Coal Mine (39°24′21″N, 110°9′47″E), Syrup Canal Coal Mine (39°24′21″N, 110°10′2″E) and Liu Shipan Coal Mine (39°22′59″N, 110°10′12″E), respectively, set up sample plots, carry out different methods of soil organic reconstruction test and vegetation restoration research, and set lysimeter And soil respiration measurement sample points, design the vegetation photosynthesis measurement time, frequency and method in the area. Combined with remote sensing technology, the observational data is used to improve the representative land surface model DLM (Chen et al., 2013; Sun et al., 2016, 2017) and CLM4.5 (Oleson et al., 2013) subgrid vegetation functional types. The LUCC parameterization scheme at the level optimizes the key parameters of the simulated ET and photosynthesis processes, so that the improved and optimized model can accurately describe the disturbance of soil organic reconstruction process on ET and GPP, and predict the future climate and ecological environment in the region. Impact. Aiming at the problems such as soil pollution and ecological environment degradation in the mined-out area of coal mines, this study uses the integrated technology of land engineering and takes "process-mechanism-test-demonstration" as the main line to carry out targeted "differential remediation" and implement accurately, System integration, research and development of soil organic reorganization and vegetation reconstruction technology systems in coal mine goafs, respectively, to promote cross-cutting research in areas such as land engineering, restoration ecology, ecological hydrology, etc. The research on the impact of the process on regional ET and GPP has scientific guidance significance for scientifically carrying out land reclamation in coal mined-out areas, regulating land use methods, mitigating and adapting to climate change, and improving the ecological environment.
Acknowledgments
Financial support was supported by Research Project of Shaanxi Provincial Land Engineering Construction Group in China (DJNY2020-21).

References
[1] Arneth A., Sitch S., Pongratz J., et al., 2017. Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed. Nature Geoscience, 10: 79-84.
[2] Arup S, Mitra A K. Reclamation of mining-generated wastelands at alk-usha Gopalpur abandoned open cast project, ranging coalfield eastern India [J]. Environmental geology. 2002(1):39-47.
[3] Beer C., Reichstein M., Tomelleri E., et al., 2010. Terrestrial gross carbon dioxide uptake: Global distribution and covariation with climate. Science, 329: 834-838.
[4] Bonan G. B., Lawrence P. J., Oleson K. W., et al., 2011. Improving canopy processes in the Community Land Model version 4 (CLM4) using global flux fields empirically inferred from FLUXNET data. Journal of Geophysical Research, 116: G02014.
[5] Brovkin V., Boysen L., Arora V. K., et al., 2013. Effect of anthropogenic land-use and land-cover changes on climate and land carbon storage in CMIP5 projections for the twenty-first century. Journal of Climate, 26: 6859-6881.
[6] Chen H., Dickinson R. E., Dai Y., et al., 2011. Sensitivity of simulated terrestrial carbon assimilation and canopy
[7] Chen L., Dirmeyer P. A. & Guo Z., 2018. Pairing FLUXNET sites to validate model representations of land-use/land-cover change. Hydrology and Earth System Sciences, 22: 111-125.
[8] Cheng L., Zhang L., Wang Y. P., et al., 2017. Recent increases in terrestrial carbon uptake at little cost to the water cycle. Nature Communications, 8: 110.
[9] Deng X., Zhao C. & Yan H., 2013. Systematic modeling of impacts of land use and land cover changes on regional climate: A review. Advances in Meteorology, 2013: 1375-1383.
[10] Devaraju N., Bala G. & Nemani R., 2015. Modelling the influence of land-use changes on biophysical and biochemical interactions at regional and global scales. Plant Cell and Environment, 38: 1931-1946.
[11] Jung M., Reichstein M. & Schwalm C. R., 2017. Compensatory water effects link yearly global land CO2 sink changes to temperature. Nature, 541: 516-520.
[12] Krause A., Pugh T. A. M., Bayer A. D., et al., 2017. Global consequences of afforestation and bioenergy cultivation on ecosystem service indicators. Biogeosciences, 14: 4829-4850.
[13] Lai L., Huang X., Yang H., et al., 2016. Carbon emissions from land-use change and management in China between 1990 and 2010. Science Advances, 2: e1601063.
[14] Lawrence D. M., Hurtt G. C., Arneth A., et al., 2016. The Land Use Model Intercomparison Project (LUMIP) contribution to CMIP6: Rationale and experimental design. Geoscientific Model Development, 9: 2973-2998.
[15] Lawrence P. J. & Chase T. N., 2010. Investigating the climate impacts of global land cover change in the community climate system model. International journal of climatology, 30: 2066-2087.
[16] Lee X., Goulden M. L., Hollinger D. Y., et al., 2011. Observed increase in local cooling effect of deforestation at higher latitudes. Nature, 479: 384-387.
[17] Li R. & Arora V. K., 2012. Effect of mosaic representation of vegetation in land surface schemes on simulated energy and carbon balances. Biogeosciences, 9: 593-605.
[18] Li W., Ciais P., Peng S., et al., 2017a. Land-use and land-cover change carbon emissions between 1901 and 2012 constrained by biomass observations. Biogeosciences, 14: 5053-5067.
[19] Liu M., Tian H., Lu C., et al., 2012. Effects of multiple environment stresses on evapotranspiration and runoff over eastern China. Journal of Hydrology, 426-427: 39-54.
[20] Liu M., Tian H., Lu C., et al., 2012. Effects of multiple environment stresses on evapotranspiration and runoff over eastern China. Journal of Hydrology, 426-427: 39-54.

[21] Madhusoodhanan C. G., Sreeka K. G. & Eldho T. I., 2017. Assessment of uncertainties in global land cover products for hydro-climate modeling in India. Water Resources Research, 53: 1713-1734.

[22] Malyshev S., Shevliakova E., Stouffer R. J., et al., 2015. Contrasting local versus regional effects of land-use-change-induced heterogeneity on historical climate: Analysis with the GFDL earth system model. Journal of Climate, 28: 5448-5469.

[23] Ménard C. B., Ikonen J., Rautiainen K., et al., 2015. Effects of meteorological and ancillary data, temporal averaging, and evaluation methods on model performance and uncertainty in a land surface model. Journal of Hydrometeorology, 16: 2559-2576.

[24] Pielke R. A., Pitman A., Niyogi D., et al., 2011. Land use/land cover changes and climate: Modeling analysis and observational evidence. Wiley Interdisciplinary Reviews, 2: 828-850.

[25] Sterling S. M., Ducharne A. & Polcher J., 2012. The impact of global land-cover change on the terrestrial water cycle. Nature Climate Change, 3: 385-390.

[26] Sun S., Chen B., Shao Q., et al., 2017. Modeling evapotranspiration over China’s landmass from 1979 to 2012 using multiple land surface models: Evaluations and analyses. Journal of Hydrometeorology, 18: 1185-1203.

[27] transpiration to different stomatal conductance and carbon assimilation schemes. Climate Dynamics, 36: 1037-1054

[28] Yan J. W., Liu J. Y., Chen B. Z., et al., 2014. Changes in the land surface energy budget in eastern China over the past three decades: Contributions of land-cover change and climate change. Journal of Climate, 27: 9233-9252.

[29] Yan J. W., Liu J. Y., Chen B. Z., et al., 2014. Changes in the land surface energy budget in eastern China over the past three decades: Contributions of land-cover change and climate change. Journal of Climate, 27: 9233-9252.

[30] Yang Q., Tian H., Li X., et al., 2015. Spatiotemporal patterns of evapotranspiration along the North American east coast as influenced by multiple environmental changes. Ecohydrology, 8: 714-725.

[31] Zhang M., Lee X., Yu G., et al., 2014. Response of surface air temperature to small-scale land clearing across latitudes. Environmental Research Letters, 9: 034002.

[32] Zhang, Jixiong, Li, et al. Properties and Application of Backfill Materials in Coal Mines in China[J]. Minerals, 2019.

[33] Chen Guangsheng & Tian Hanqin, 2007. Impact of land use / cover change on terrestrial ecosystem carbon cycle. Chinese Journal of Plant Ecology, 31: 189-204.

[34] Fang Rongrong. Analysis of seismic response characteristics of coal mine goaf [D]. Taiyuan University of Technology, 2018.

[35] Gao Yansheng, Ji Zonghao, Wang Luping. Status Quo Analysis and Control of Coal Mining Subsidence in Jining City [J]. Coal Mine Modernization, 2009, 2009 (z1): 75-76.

[36] Han Changchang, Introduction to Land Engineering [M]. Beijing: Science Press, 2013.

[37] Han Changchang, Principles of Land Engineering [M]. Beijing: Science Press, 2017.

[38] Li Quansheng. Study on the Ecological Restoration Technology for the Development of Coal Power Bases in the Eastern Steppe Region [J]. Chinese Journal of Ecology, 2016 (22).

[39] Liu Jiyuan, Kuang Wenhui, Zhang Zengxiang, et al. 2014. Basic characteristics and spatial pattern of land use change in China since the late 1980s. Acta Geographica Sinica, 69: 3-14.

[40] Shao Yan & Zeng Xiaodong, 2012. Research progress on the impact of land use and land cover change on the climate system. Climate and Environmental Research, 17: 103-111.

[41] Wang Yuanyuan, Xie Zhonghui, Jia Binghao, et al. 2015. Simulation and assessment of total primary vegetation productivity in China based on land surface process model CLM4. Climate and Environmental Research, 20: 97-110.