Analysis of New Energy and Environmental Factors and Economic Benefits of Urban Land Use

WanShu Dong[1], Wenlan Xie[1] * and Fan Wu[2]

[1] Pingdingshan Polytenchnic College
Pingdingshan, Henan (China)

[1] School of Business
The University of Sydney
Sydney, New South Wales (Australia)
E-mail: **wxie3035@uni.sydney.edu.au**

[2] China University of Mining and Technology
Beijing (China)

Abstract. From the perspective of urban economy and new energy and environmental factors, this study constructed a coupled coordination model of new energy and environmental factors and research on The relationship between land use efficiency and economy, and from 2012 to 2022, the panel data of 15 cities in Gansu Province was empiractively studied. According to the research and analysis, the balance of the new energy and environmental factors based on machine learning and Promote the overall development of economic benefits and optimize the energy environment. The research results in the group show that environmental factors can effectively promote the improvement of economic benefits and realize economic structural reform, which is conducive to the green, low-carbon, energy saving and environmental protection of urban development, strengthen urban land planning, and promote the reform and upgrading of urban structure.

Key words. Machine Learning, New Energy, Environmental Factors, Urban Land Use, Economic Benefits.

1. Introduction

The economic benefits of urban land use, as the name suggests, are the beneficial results of the use of land, which covers the economy, society and new energy environment [1]. With the rapid growth of the social economy, the deepening of urbanization and the strict supervision of land use, land resources have become more and more important, and the conflicts of various benefits brought by land use in cities are becoming more and more obvious. Now, China has promoted the protection of the new energy and environment to a new level, and the rough development of resources should be stopped [2]. In the process of developing the land to promote local economic development, the city should think about how to balance the dual benefits of ecology and economy, so as to improve

the harmony between them. Nowadays, some scholars have used the DEA method to conduct in-depth research and analysis on the comprehensive benefits of urban land use in some prefecture-level cities. [3], [4]. Some scholars hope to further study the land use efficiency in Northeast China by using the coupling coordination degree model [5], [6]. Gansu Province was taken as the research object, and the panel data of 15 cities in the province were collected. The study will discuss the coordinated development of urban land use, its economic benefits, and new energy and environmental factors in various cities in Gansu province from 2012 to 2022. This study will analyze the coordinated development degree, trend and reasons for these two benefits, comprehensively explore the new energy and environmental factors based on machine learning and the economic benefits of urban land use, scientifically promote green development, and it has increased the living comfort of Gansu Province and improved the level of comprehensive economic development.

2. Research Methods

A. *Construction of the Index System*

Based on the machine learning algorithm, it is necessary to determine the relationship between urban land use efficiency and new energy environmental factors, and it is necessary to construct a scientific evaluation index system, which is a key step to measure the above two systems [7], [8]. In designing the index system, this research adheres to the criteria of science, clear goal, system integrity, autonomy and measurablity, and tries to reduce the volume difference of each city. At the same time, this study draws on the research results of other scholars to create a set of index systems including urban land use efficiency

indicators and new energy and environmental factors assessment, as shown in Table 1.

Table 1. Economic Benefit of Urban Land Use and Evaluation Index System of New Energy and Environmental Factors

Evaluation Level	Evaluating Indicator	Unit	Indicator Attributes
Economic Benefits	The Proportion of the Urban Built-up Area in the Urban Area	%	Forward Direction
	Gross Local Fiscal Revenue	Ten Thousand Yuan / sq. km 2	Forward Direction
	Output Value of the Secondary and Tertiary Industries Per Land	RMB 100 Million Yuan / Square Kilometer	Forward Direction
	Ground Average Fixed Assets Investment	RMB 100 million yuan / square kilometer	Forward Direction
	Per Capita GDP (Ten Thousand Yuan / Person)	Ten Thousand Yuan / Person	Forward Direction
	The Proportion of the Tertiary Industry in GDP	%	Forward Direction
	Total Retail Sales of Consumer Goods Per Capita	Ten Thousand Yuan / Person	Forward Direction
	Per Capita Local Fiscal Revenue	First	Forward Direction
	Annual Per Capita Disposable Income Of Urban Households	First	Forward Direction
New Energy and Environmental Factors	Per Capita Park Green Space Area	m2	Forward Direction
	The Proportion of the Garden Green Space Area in the Urban Area	%	Forward Direction
	Spending on Energy Conservation and Environmental Protection Accounts in Government Spending	%	Forward Direction
	Green Vegetation Coverage in Urban Areas	%	Forward Direction
	Number of Days when the City's Air Quality Reached an Excellent Level	sky	Forward Direction
	Inhalable Particulate Matter (PM10)	mg / m 3	Negative Direction
	Total Discharge of Industrial Wastewater Per Ground	Ten Thousand Tons / sq 2	Negative Direction
	Total Industrial Exhaust Gas Emissions Per Ground Level	YiBiao Cubic Meters / Square Kilometers	Negative Direction
	The Production Amount of Industrial Solid Waste Per Ground Level	Ten Thousand Tons / sq 2	Negative Direction

B. Data Sources

The data of this study were mainly obtained from the Statistical Yearbook of Gansu Province and the Statistical Bulletin of National Economic and Social Development. In case of missing data, the study replaces the average of these data from adjacent years.

1) Data Normalization

Given that the evaluation criteria cover many fields and have different related characteristics, the data must be normalized. When it comes to judging the merits of the evaluation index, the study uses the following equations to standardize.

For the forward indicators:

$$X'_{cij} = \frac{X_{cij} - \min(X_{cij})}{\max(X_{cij}) - \min(X_{cij})} \qquad (1)$$

For the negative indicators:

$$X'_{cij} = \frac{\max(X_{cij}) - X_{cij}}{\max(X_{cij}) - \min(X_{cij})} \qquad (2)$$

In the formula, i represents the year, the value of i is 1, 2, 3, ..., m; j represents the index of item j, j=1, 2, 3, ..., n; c represents c local city, where c=1, 2, 3, ..., 15; X_{cij} represents the initial data of item j in year i, while X'_{cij} is the standardized value of item j of prefecture-level city in year i c.

C. Index Empowerment

For the correctness of the evaluation index of new energy environmental factors and the economic index of urban land use, the entropy method is used to determine the weight of the index. The introduction of time variables into metrics increases the accuracy of weight settings. The specific calculation results can be found in Table 2 statistics. Index entropy value of item *j*:

$$E_j = -k \sum_{i=1}^{m} \sum_{c=1}^{16} y_{cij} \ln y_{cij} (k = \frac{1}{\ln m}) \qquad (3)$$

$$y_{cij} = X'_{cij} / \sum_{j=1}^{m} \sum_{c}^{16} X'_{cij} \qquad (4)$$

Where, when $y_{cij}At=0$, $y_{cij}lny_{cij}=0$, the index entropy right of item *j*:

$$w_j = \frac{1 - E_j}{n - \sum_{j=1}^{n} E_j}, \sum_{j=1}^{n} w_j, j = 1, 2, 3, \cdots, n \qquad (5)$$

D. The Comprehensive Development Level Index Calculation

After assigning the weight of the relevant indicators of the influencing factors, this study uses the linear weighting method to establish the overall economic benefits of the city (U1) And the new energy and environmental factors (U2), The comprehensive development level index.

$$U_1(U_2) = \sum_{j=1}^{n} X'_{cij} W_j \qquad (6)$$

In the formula, *j*=1, 2, 3, ... n, X'cijThe normative value representing the index of item *j* in the year *i c*, W_j It is the weight of the item *jth* index.

Table 2. The Weight of the Influence Factors on Economic Benefits Use and Evaluation Indicators of New Energy and Environmental Factors

Evaluating Indicator	Weight
The Proportion of the Urban Built-up Area in the Urban Area	0.0556
Gross Local Fiscal Revenue	0.0570
Output Value of Output Per Hectare of Land	0.0569
Ground Average Fixed Assets Investment	0.0568
Per Capita GDP (Ten Thousand Yuan/Person)	0.0565
Environmental Factors in GDP	0.0574
Total Retail Sales of Consumer Goods Per Capita	0.0574
Per Capita Local Fiscal Revenue	0.0569
Annual Income of Urban Households	0.0564
Per Capita Park Green Space Area	0.0549
The Proportion of the Garden Green Space Area in the Urban Area	0.0563
Spending Accounts in Government Spending	0.0589
Environmental Factors and Energy in Building Areas	0.0557
Environmental Factors than Level 2	0.0521
Inhalable Particulate Matter (PM10)	0.0546
Total Discharge of Industrial Wastewater Per Ground	0.0515
Total industrial Exhaust Gas Emissions Per Ground Level	0.0540
The Production Amount of Industrial Solid Waste Per Ground Level	0.0512

E. Coupled Coordination Degree Model Construction

It is necessary to dig deep into the coupling relationship between environmental factors and economic factors and the new energy and environment factors.

$$C = \frac{2 \times \sqrt{U_1 \times U_2}}{U_1 + U_2} \qquad (7)$$

In-depth analysis of the relationship between the environment and promoting factors and economic development, verification of the coupling structure between economic development and the environment, and at the same time, the weight of the data must be assigned, and the value range is between 0 and 1, so as to improve accuracy of economic factor development research. If *C*=1, it indicates that the relationship between new energy and environmental factors and urban land use efficiency is shared. If *C*=0, there is no interaction between new energy and environmental factors and urban utilization efficiency.

Therefore, when there is an impact between the environmental factors of new energy and the economic benefits of urban land use, the degree of coupling *C* can be used to describe the degree of influence between the two. However, if the benefits are relatively small, this study would be possible to obtain greater coupling degree data. Therefore, this study established a coupled coordination degree model, the purpose is to truly show the economic benefits of urban land use and the synergistic effect and coordination degree of new energy and environmental factors.

$$D = \sqrt{C \times T}, T = (aU_1 + bU_2) \qquad (8)$$

In the formula (8), *D* represents the rapport of the new energy and environmental factors based on machine learning and the increasing rate of environmental factors under unit economic constraints., *T* is an indicator of the overall rapport of the economic benefits, and *a* and *b* are the parameters to be evaluated. Usually, the sum of *a* and *b* is 1. Given the equal economic benefits of urban land and

the benefits of the new energy environment, the values of *a* and *b* were set at 0.5. Therefore, the correlation range and coordination degree of the new energy and environmental factors and the economic benefits of urban land use in Gansu Province are constructed, as detailed in Table 3.

Table 3. Coordination Degree Intervals and Grades

Coordination Interval	Coordination Level
1*logx	Very Serious
2*logx	More Serious
3*logx	General Results
4*logx	A Compromise
5*logx	Normal
6*logx	Relatively Good
7*logx	Good
8*logx	Very Good
9*logx	Excellent
10*logx	Beyond Imagination

Note: * logx is the zoom-in and zoom-out function, and x is the fetched data result.

3. Empirical Analysis

A. Economic Benefits of Urban Land Use and Timing Changes of New Energy and Environmental Factors

Using the mathematical model mentioned earlier, this study can calculate the economic benefit index and the new energy and environmental factor index of urban land in Gansu province from 2012 to 2022, and analyze the relevant correlation and coordination.

From 2012 to 2022, the coupling degree of the utilization rate of the land use and new energy environment factors in Gansu Province is between 0.6814 and 0.9999997, which has generally experienced the process of evolution from running-in to a high level. From 2012 to 2015, the coupling degree increased rapidly and reached the highest value of 0.999997 in 2017, and in 2022, Overall economic benefits in urban land use and new energy environmental factors in Gansu Province were slightly weakened, but the correlation remained at a high level. According to the development trend of the economic index (U) and new energy and environment index (U), this study shows that the economic benefits and environmental benefits of urban land use in Gansu Province in 2017 are undergoing a transformation stage. From 2018 to 2022, the degree of coupling has been in the range of 0.9717 to 0.9834, and it has always maintained a relatively high degree of coupling and stability, the change in coupling is shown in Figure 1.
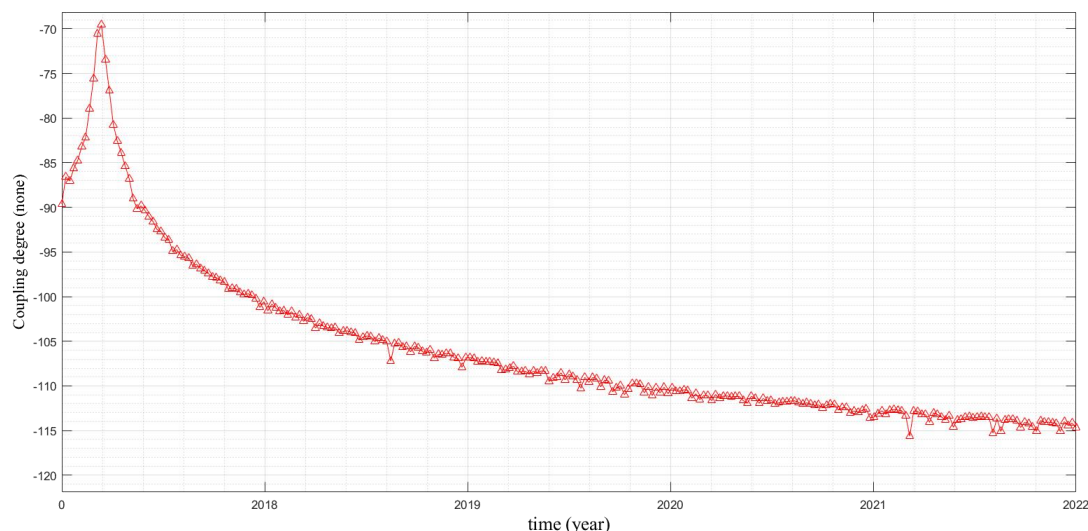

Figure 1. Change in coupling degree from 2018 to 2022

Looking at its coordination, this study shows that its value is between 0.2918 and 0.6374, and it has been growing. This shows the overall economic benefits brought by new energy. In Gansu province, the situation has changed from a slight imbalance to a preliminary coordination stage. In 2012, it had the worst coordination and was in a moderate imbalance. Over the course of the past two years, imbalances eased in 2014 and coordination shifted from serious to minor imbalances. During the period from 2015 to 2018, the balance between the degree of environmental improvement and the new energy and environmental factors in Gansu Province is gradually deteriorating. Since 2017, this study has entered the stage of vigorous coordination, and the degree of coordination has been constantly improving. From 2021 to 2022, the coordination relationship between the degree of environmental

improvement and the new energy and environmental factors in Gansu Province has entered the primary stage of coordination, and showed a certain upward trend. Between 2012 and 2018, the difference between the new energy environmental factors and the degree of environmental improvement can be divided into two periods: first, the new energy environmental factors exceeded the economic benefits before 2018; second, after 2018, the economic benefits exceeded the new energy environmental factors after 2018. For 11 years ago, the overall benefit of urban land use in Gansu province has been steadily improving, at the same time, its new energy environment factor benefit has only slightly increased, this shows that the urban economic growth in Gansu province is quite fast, the economic benefit of urban land use has maintained a growth trend, even in 2018 has gone beyond the urban land use of new energy environmental factor benefits. However, in the late stages of urban land use, it pays more attention to economic benefits, but fails to fully consider its impact on the new energy and environmental factors, which makes the difference between the two gradually expand.

B. The Coupling of Economic Benefits and New Energy and Environmental Factors in 15 Prefecture-Level Cities

According to the economic benefit index of urban land use and new energy environment factor index calculation method and related coupling and coordination model, the study of 15 cities between 2012 to 2022 city land use of economic benefit index, new energy environment factor index and related coupling and coordination between the measurement. In view of the constraints of length, data from 2021-2022 were selected as the study year. According to the scope of coordination, the economic benefits of land use and the benefits of new energy and environmental factors in 15 local cities in Gansu Province were divided, and are listed in Table 4. According to the data in Table 4, in 2012, the economic coupling benefits of urban land use and new energy environmental factors of 15 prefecture-level cities in Gansu Province reached 0.6899 on average, while the coordination degree was between 0.0855 and 0.3835. The coordination of these three degrees could be divided into slight, moderate, and severe, the correlations of the data are shown in Figure 2.
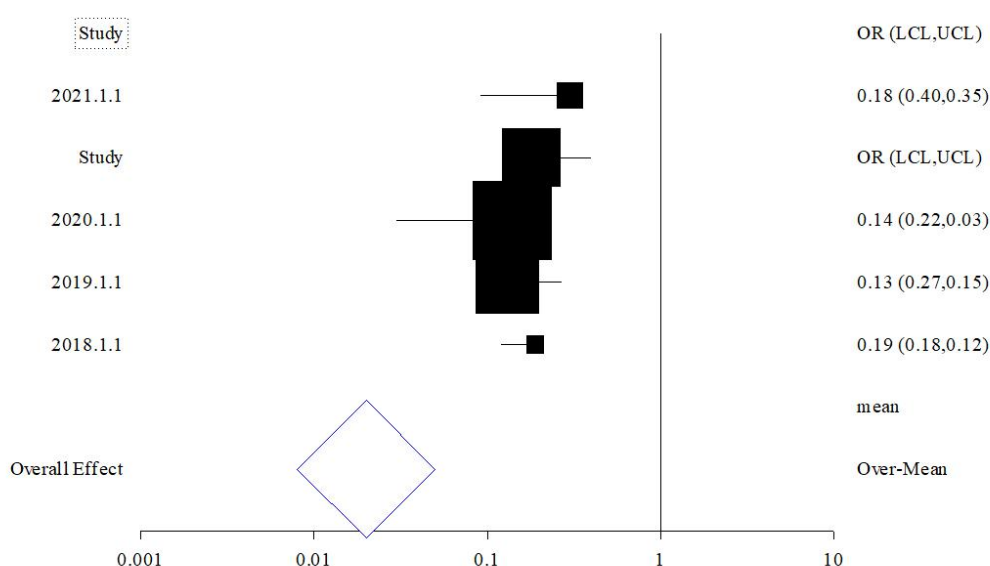

Figure 2. Correlation Between New Energy Environmental Factors of Land Use And Economic Benefits

From the data analysis in Figure 2, there is a large correlation between the use of land resources and environmental economic benefits from January 1, 2018, to January 1, 2022. The overall impact is greater than 0.5, which is on the right side of the average The position shows that the degree of correlation between the two is high, and environmental factors can promote the development of economic benefits and achieve effective improvement of economic benefits. From 2012 to 2022,

the correlation between the new learning-based energy and environmental factors of machine learning and the degree of environmental improvement in 15 prefecture-level cities in Gansu Province has gradually evolved from the tertiary slight or moderate imbalance to the dual situation of basic balance and vigorous balance. In addition, the overall results of the impact of environmental factors on economic factors are shown in Table 4.

Table 4. Correlation Between New Energy and Economic Benefits from 2018 to 2022

	2018	2019	2020	2021	2022
2018	1				
2019	0.993**	1			
2020	0.980**	0.993**	1		
2021	0.997**	0.995**	0.983**	1	
2022	0.990**	0.996**	0.992**	0.992**	1

Note: * represents difference, * * represents significant difference.

It can be seen from Table 4 that there is a significant correlation between new energy environmental factors and economic benefits from 2018 to 2022, indicating that new energy environmental factors can promote the improvement of economic benefits. By observing the mutual correlation and balance of the economic environmental gains. use and the benefits of the new energy and environmental factors of all the county-level cities in Gansu Province, it can be found that the difference is not obvious. Therefore, there are also significant differences in the relevant urban development orientation. The main goal of this study is to cover all local-level cities in Gansu province, which do not cover all counties and towns, so the overall economic growth and land use efficiency cannot be regarded as matching the economic growth and land use efficiency of all local cities.
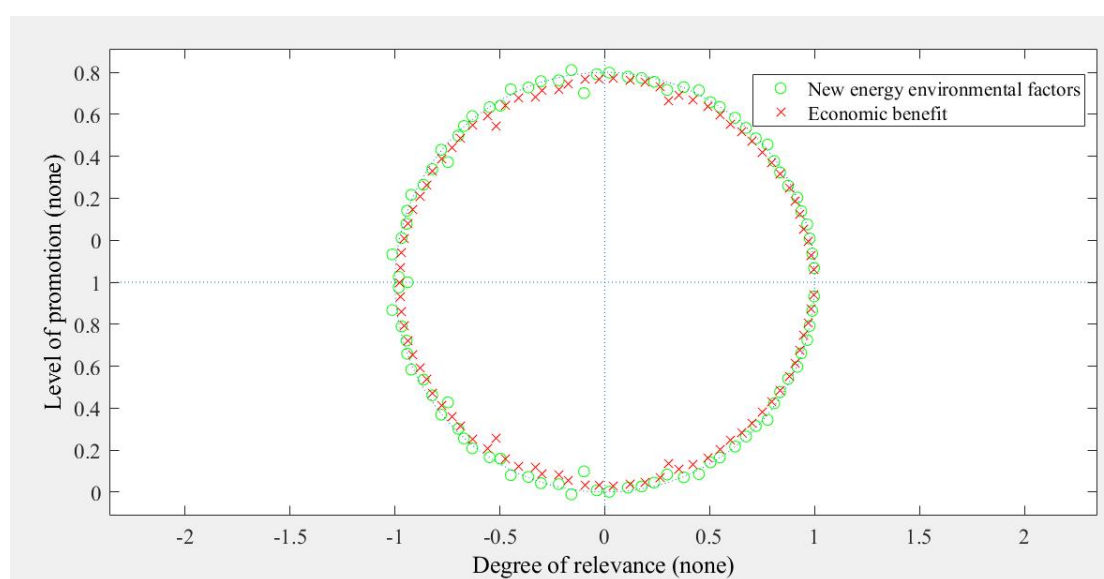

Figure 3. Iterative Process Between New Energy Environmental Factors and Economic Benefits

Through the data analysis in Figure 3, there is an entanglement relationship between the new energy environmental factors and the economic benefits, and the two have been ups and downs in the radius of the economic cycle, and promote each other, the overall degree of integration between the two is better, in addition, the new energy environmental factors have been in the periphery of the economic benefits, indicating that the influence and role of the new energy environmental factors on the economic benefits want to have a certain delay, that is to say, the new energy environmental pollution is the prerequisite for the improvement of economic benefits, and the economic benefits will also have a certain inhibitory and promoting effect on the new energy environmental factors, in the case of rapid economic development, the new energy environmental factors play a small role, and the environmental factors suffer to the greater inhibition, therefore, the new energy environmental factors have been between the rain, should present a phased rectification, in the initial stage of economic benefits, the overall effect of new energy environmental factors, under the foot of the economic benefits, the follow-up of new energy environmental factors, explain the role, if so the relationship between the new energy environmental work and the economy is to promote, balance, and inhibit. The specific process is shown in Figure 4.
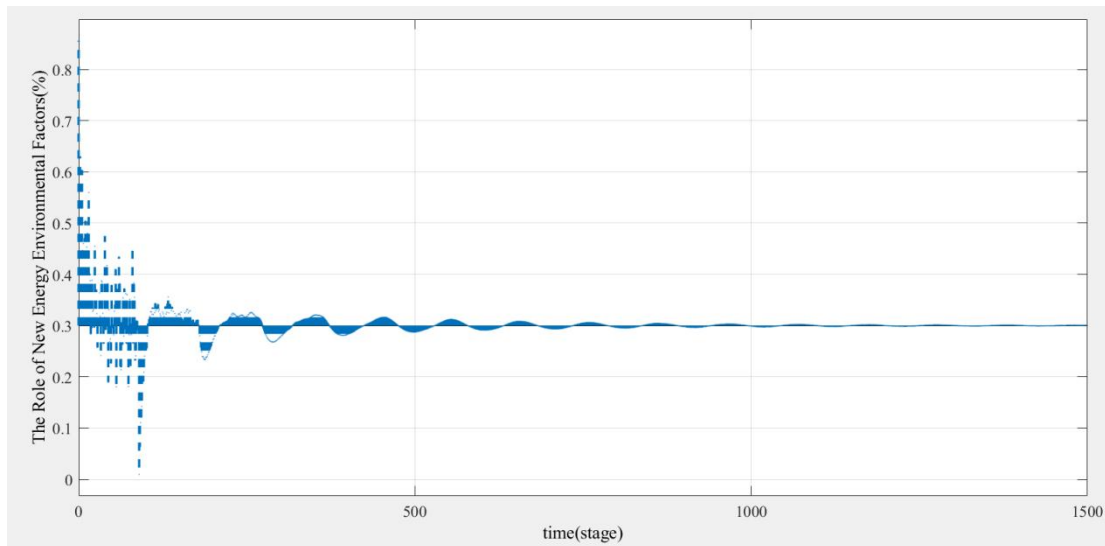
Figure 4. The Phased Role of New Energy Environmental Factors in Promoting Economic Benefits

4. Conclusions and Suggestions

A. Conclusion and Analysis

Through the establishment of the economic benefit of urban land use and the evaluation index of new energy and environmental factors, and the coupling and coordination model, the study has analyzed the economic environmental gains. use and the coupling and coordinated development degree of new energy and environmental factors between 2012 and 2022. The study results show that:

From 2012 to 2022, the economic benefit index of urban land use in Gansu province has been growing, while the benefit index of the new energy environment has also been constantly improving. Between 2012 and 2017, the ecological and environmental benefits of urban land use in Gansu province exceeded its economic benefits, and the differences between the two are gradually decreasing. From 2018 to 2022, the degree of environmental improvement in Gansu province exceeded its impact on the new energy environment, and this difference is gradually increasing, which indicates that degree of environmental improvement in Gansu province is gradually improving, while the impact on the new energy environment is relatively weak and difficult. During the study, the coupling degree of urban land use and new energy and environmental factors in Gansu Province is between 0.6814 and 0.999997, experiencing the evolution process from run-in to high level; the coordination relationship between new energy and environmental factors based on machine learning and urban land use has changed from moderate imbalance to basic coordination, within the range of 0.2918 to 0.6374. In the last stage of the study, degree of environmental improvement and the coordination degree of new energy and environmental factors in Gansu province are still in the primary coordination state. From 2012 to 2022, the economic environmental gains. use and the synergistic benefits of new energy and environmental factors varied in 15 county-level cities in Gansu Province. While developing land to promote the economy, these cities also focus on maintaining the new energy environment. Because the overall development degree of

other local cities in Gansu province is poor, it is easy to produce misleading associations. The economic development status of each city and the degree of attention to the protection of new energy and environment have a significant impact on degree of environmental improvement and the coupling and coordination degree of new energy and environmental factors. In some years and cities that are outstanding in energy conservation and pollution reduction, the benefits of the new energy and environmental factors for land use will increase substantially.

B. Suggested the Analysis

At present, the cooperation of new energy and environmental factors based on machine learning and the economic efficiency of urban land use is still in the initial stage. However, different local cities have different degrees of cooperation, and even have unreal cooperation in some cases. So, the provinces and cities must implement a strategy to build an economic benefit of land use and new energy environment factors benefit mutual cooperation and collaborative progress of persistence system, thus improving the new energy environment factors based on machine learning and degree of environmental improvement with progress, ecological protection duties, strengthen urban management, the implementation of various urban beautification activities, to improve the living environment of urban residents. Secondly, strengthen the planning of urban land to enhance the intensive use of urban land and the coverage area of urban greening. All the construction and planning agencies of local cities need to comprehensively evaluate the various land types of cities according to the local geographical conditions, historical background and development conditions, and rationally arrange the layout on the premise of ensuring economic benefits and new energy and environmental factors, so as to develop the utilization potential of urban land. The organized widening of the edge of the city and the construction area of the city are expanded to enhance the land use benefits of the existing edge area. Through the reform of the old city and the reconstruction of residential areas, the use efficiency of the

city can be improved, and while saving and rationally using the existing development land, we can stick to the three restriction lines established by the national natural resources department. In the process of increasing forest coverage and promoting public green action, all provinces and cities should use the latest environmental protection views and scientific methods to carefully select the appropriate green vegetation of the urban landscape, to improve the beauty of the urban landscape. The goal of provinces and cities is not only to increase the green coverage of cities, but to improve from a quality point of view.

Then, the fiscal and tax policies are actively used to promote the transformation and upgrading of the industrial structure in Gansu Province. Promote the structural reform of the supply chain, use financial resources to support the environmental protection industry and advanced technology industry, enhance the intensity of financial assistance, and give reductions or exemptions in tax, so as to promote the growth and expansion of the company. For highly polluting and energy-intensive industries, promote them through tax measures. Provinces and cities should strengthen environmental governance and give full play to the promoting role of the natural environment, so as to provide support for economic development and income, deepen the structure of economic development and optimize its resources.

Finally, the development path of cities should be clarified to promote the transformation and progress of resource-based cities in the province. Understand the uniqueness of each city, and give full play to the local subjective initiative in the overall coordination. Nowadays, there are significant differences in the degree of economic development, resource conditions, climate characteristics and development goals of each city. Therefore, the provinces and cities should not treat the urban construction and land use, but should make up for their shortcomings, but also expand their advantages. After a comprehensive assessment of the local natural and historical background, the provinces and cities should establish clear goals and formulate corresponding strategies. Promoting economic development and maintaining a new energy environment are the key steps to improving the living quality and living environment of the people, correctly understanding the role of prefecture-level cities in the whole province, and making ecological compensation for economically backward ecological protection areas according to the actual situation.

References

[1] R. Direya and T. Khatib, "Simplified python models for photovoltaic-based charging stations for electric vehicles considering technical, economic, and environmental aspects," *World Electric Vehicle Journal,* vol. 14, no. 4, Apr. 2023, doi: 10.3390/wevj14040103.

[2] O. Hachchadi, D. R. Rousse, M. Irandoostshahrestani, and A. Mechaqrane, "Techno-economic assessment and environmental impact of photovoltaic and conventional solar water heating systems in cold climates," *Energy Conversion and Management,* vol. 297, Dec. 2023, doi: 10.1016/j.enconman.2023.117725.

[3] M. Jafarian, E. Assareh, N. Agarwal, E. Saedpanah, and M. Y. Lee, "Energy, economic, and environmental analysis of combined cooling, heat, power and water (CCHPW) system incorporated with photovoltaic/thermal collectors and reverse osmosis systems," *Journal of Building Engineering,* vol. 75, Sep. 2023, doi: 10.1016/j.jobe.2023.107059.

[4] S. E. Kabir *et al.*, "Analysing economic feasibility of recycling end-of-life solar photovoltaic modules of Bangladesh," *Clean Technologies and Environmental Policy,* vol. 25, pp. 3231–3245, Oct. 2023, doi: 10.1007/s10098-023-02613-0.

[5] A. Kowsar *et al.*, "Optimization and techno-economic assessment of 50 MW floating solar power plant on Hakaluki marsh land in Bangladesh," *Renewable Energy,* vol. 216, Nov. 2023, doi: 10.1016/j.renene.2023.119077.

[6] Q. X. Li, C. Monticelli, A. Kutlu, and A. Zanelli, "Feasibility of textile envelope integrated flexible photovoltaic in Europe: Carbon footprint assessment and life cycle cost analysis," *Journal of Cleaner Production,* vol. 430, Dec. 2023, doi: 10.1016/j.jclepro.2023.139716.

[7] M. Orlando, L. Bottaccioli, S. Quer, M. Poncino, S. Vinco, and E. Patti, "A framework for economic and environmental benefit through renewable energy community," *IEEE Systems Journal,* vol. 17, no. 4, pp. 5626-5635, Dec. 2023, doi: 10.1109/jsyst.2023.3290941.

[8] F. Rodríguez-Mas, D. Valiente, J. C. Ferrer, J. L. Alonso, and S. F. de Avila, "Towards a greener photovoltaic industry: Enhancing efficiency, environmental sustainability and manufacturing costs through solvent optimization in organic solar cells," *Heliyon,* vol. 9, no. 12, Dec. 2023, doi: 10.1016/j.heliyon.2023.e23099.