Dynamic Coupling Analysis of Reclamation Land Utilization and Social-Economy Development, a Case Study of Zhejiang Province

Zeyu Gao[1,2] and Jun Wang[1(✉)]

[1] College of Information Engineering, Zhejiang University of Water Resources & Electric Power, Hangzhou 310018, China
swiftone@163.com
[2] School of Information Engineering, Huzhou University, Huzhou 313000, China

Abstract. A dynamic coupling model with ecology factors of reclaimed land utilization and social-economy development was constructed for case study of coastal cities of Zhejiang. According to the results, firstly, the coupling of reclaimed land utilization and social-economy development were totally in a small value less than 1, where effectiveness of social-economy development was dominated. Secondly, there were three patterns of dynamic coupling in 7 cities that those four cities of Hanghzou, Jiaxing, Taizhou and Wenzhou were in the pathway of regeneration, two cities of Shaoxing and Ningbo were in the pathway of extreme development and Zhoushan was in the pathway of coordination development. Thirdly, related policies should be implemented timely to ensure effective cohesion and smooth entrance from old coupling pathway to a new one with more effectiveness.

Keywords: Sustainable Development · Dynamic Coupling Analysis · Coordinate Development

1 Introduction

As a precious nature resource, different utilizations of land are exclusive in agriculture, ecology, industry, real estate development. Whereabouts transferring of land utilization from agriculture and ecology to industry or real estate are strongly irreversible in a long time. So it is very important to make land utilization more sustainable to serve the main objective of ecology civilization construction. With great progress of social-economy development in land utilization with the rule of GDP chasing mainly, great damage were still suffered in environment and ecology in the past decades. In ecology civilization construction, ecology and sustainable development including the life community with mountains, water, forest, fields, lakes and others is the main goals of land utilization, as well as urbanization, modernization, etc., no longer only one primary goal, GDP. In such framework, the dynamic coupling degree of reclaimed land utilization and social-economy development could be an important index to evaluate the effectiveness of land utilization in ecology civilization construction.

M. F. b. Sedon et al. (Eds.): SSHA 2023, ASSEHR 752, pp. 404–412, 2023.
https://doi.org/10.2991/978-2-38476-062-6_51

Based on relationship analysis of reclaimed land utilization and social-economy development, ecological factors were introduced to compare the dynamic coupling process of different regions in the whole framework of ecological civilization construction with reclaimed land utilization system described by agriculture utilization, industry utilization, urbanization utilization and ecological utilization, and social economy development system described by economic output, economic quality, urban construction and social progress. The dynamic coupling model was applied in the empirical study of 7 coastal regions of Zhejiang province for comparing analysis of dynamic coupling process of reclaimed land utilization and social-economy development.

2 Coupling Model

As an important tool in system science, coupling, derived from physical theory in natural science, was wildly applied in social science. Some scholars analyze and measured the coupling degree of urbanization and other aspects in urban development [1, 2], etc. Some scholars studies in industry agglomeration and development [3, 4]. Some scholars focused on technical innovation [5, 6] tried to measure and analyze the coupling degree of technical innovation and economy development. There were some studies about coupling mechanism, measurement, and sustainable development in ecology [7, 8].

In view of the concept of capacitive coupling in physics, capacitive coupling model measures the coupling degree of multiple systems or factors with the coefficient of capacitive coupling, calculating. Several stages may be defined according to different value intervals to measure the coupling degree of multiple systems in convenience [5, 9, 10]. System evolution coupling model was constructed based on the relationship and evolution tendency of coupling systems, which can be described in the follow equations.

$$\begin{cases} A = \frac{dS_1}{dt} = f_1(S_1, S_2) \\ B = \frac{dS_2}{dt} = f_2(S_1, S_2) \end{cases} \tag{1}$$

S1 and S2 were evaluations of the two systems with respectively evaluation index system, A and B were the equation of evolution of the two systems with internal or external influences. A and B were both affected by S1 and S2, which made them evolve as a whole system. In view of dynamic evolution of one system often in form of S curve and varying periodically, angle values in four quadrants was classified into four stages of dynamic coupling degree, which were low symbiosis stage (I), coordination development stage (II), extreme development stage (III) and regeneration development stage (IV), as Fig. 1 shows. In view of unknown theory equation of A and B, fitting curve were often adopted to approximate the system behaviors. The approximation equations can be used in formula (4) and formula (5) for dynamic coupling analysis.

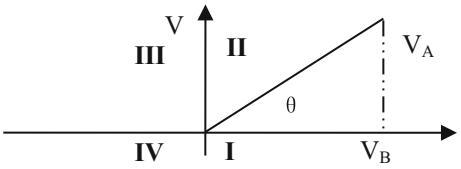

Fig. 1. Four Stages of Coupling

3 Empirical Model Construction

3.1 Basic Information of Research Regions

Zhejiang province is a geography small province, covering a little bit more than 100 thousand square kilometers, only about 1.1% of China. Furthermore, about 74.63% area of Zhejiang is mountain or hill, and only 20% can be used for farmland or urban construction. Cultivated land covers only 208.17 million hectares totally in Zhejiang. The contradiction between man and land was always serious. Meanwhile, Zhejiang province is an economic big province of top 4 regions in China with more than $1,3600 per capita GDP in 2017, over the income threshold level of high-income countries according to the national classification standards 2017 of World Bank. Fortunately, Zhejiang has the most coastlines the country with 6486.24 km. Great deal of incoming sediments transported by Yangtze River and other coastal rivers toward the East Sea has formed many beach zones with high density of sediments from north to south of costal Zhejiang in the long history. Those zones formed widely shoals with sediments slowly settling under the affection of water flow and waves. Therefore, there are abundant resources of shoals in Zhejiang, about 13% of total shoals resources of China, and mainly in siltation and stable type.

Very limited land resources of Zhejiang as a geography small province could not support rapid progress of social economy enough, ask for land from shoals" has been the most important strategy to enlarge development space, and relieve contradiction of land of those coastal regions hundreds of thousands of years, and also was one of the main factors to support a big province in economy. It provided valuable land resources for all kinds of economic constructions and society development, guaranteed the strong vitality and competitiveness of economic growth, and played a very important role in promoting the sustainable development of economic society in Zhejiang province.

3.2 Data Processing

There were several types of data with different units. So values of some indicators would be very large than some others that small data would be ignored, no matter the indicators were important or not. Standardization all data to a same scale was often adopted to avoid this problem.

There were two types of methods to get weights which are objective methods and subjective methods. If mature experiences were available, scoring method, DELPHI method, AHP method, etc. would be a good choice. If not, objective methods were recommended, such as principal component analysis, entropy method and multi-objective

programming method, etc. Weights were calculated based on known knowledge from information transferred to decision maker in entropy method, one of the most popular weights evaluation methods. There were no obviously mature experiences of the coupling model for reclaimed land utilization and social economy development, so the entropy method with three steps as follow was adopted in this paper.

$$\begin{cases} w_i = \dfrac{1 - E_i}{m - \sum\limits_{i=1}^{m} E_i}, \sum\limits_{i=1}^{n} w_i = 1 \\ E_i = \dfrac{1}{\ln n} \sum\limits_{j=1}^{n} \left(\dfrac{X_{ij}^{'} + 1}{\sum\limits_{j} X_{ij}^{'} + 1} \times \ln \dfrac{X_{ij}^{'} + 1}{\sum\limits_{j} X_{ij}^{'} + 1} \right) \end{cases} \tag{2}$$

In the above formula, j was represented for the subscript of variables from sample and j = 1, 2, …, n, and i was for the subscript of indicators from sample and i = 1, 2, …, m.

4 Case Study

As a coastal province to the East Sea, seven cities are coastal cities or located by the estuary of Qiantang River, which are Hangzhou (HZ for short), Jiaxing (JX), Shaoxing (SX), Ningbo (NB), Taizhou (TZ), Wenzhou (WZ) and Zhoushan (ZS). Consequently, almost all shoal resources are distributed in those seven cities. The size of bubbles in the figure illustrated the accumulated amount of reclaimed land till 2015. History statistical data over 10 years of selected indicators were collected from statistical reports such as "Zhejiang Statistical Yearbook", "Zhejiang Reclamation Statistical Yearbook", "Cities Statistical Yearbook of China", etc., and database platform of EPS (http://olap.epsnet.com.cn), for dynamic coupling comparison analysis of those seven shoal regions of Zhejiang based on the theory of coupling.

In view of no obvious tendency of linear curve, exponential curve, or growth curve, polynomial fitting was adopted to approximate the dynamic tendency curve of evaluation as the following equation.

$$S_1 = \alpha_1 t + \alpha_2 t^2 + \cdots + \alpha_n t^n + c + \varepsilon \tag{3}$$

With most parameter tests acceptable in Eviews listed in Table 1, such as closing enough to one for R-squared, probability values within significant level, and no obviously abnormal test results.

According to scores tendency of all coastal cities evaluated with weights, generally evaluation of all cities were in an ascending trend with a sharp rise in 2004, as Fig. 2 shows. Hangzhou, Ningbo and Jiaxing were the top 3 cities with obvious gaps, and the other four cities scores close with tiny fluctuation except Taizhou.

The entirety tendency of evaluation scores of all the seven coastal cities were almost the same and similar to the Gompertz curve, one of the growth curve. But there should be to types of growth curve for an obvious step cross in 2004 for all curves. Because

Table 1. Parameter Estimation Results of Land Utilization Evaluation

	$\alpha_1\alpha_1$	$\alpha_2\alpha_2$	$\alpha_3\alpha_3$	$\alpha_4\alpha_4$	$\alpha_5\alpha_5$	**C**
HZ	0.068163	-0.00848	0.000331	0	0	0.350358
JX	0.009723	-0.00159	7.16E-05	0	0	0.415671
SX	0.004959	0	0	0	0	0.429063
NB	0.002938	0	1.31E-05	0	0	0.447725
TZ	0.006573	0	0	0	2.76E-08	0.439135
WZ	0	0.001576	-0.00022	8.61E-06	0	0.430417
ZS	0	0	7.79E-05	-2.54E-06	0	0.439987

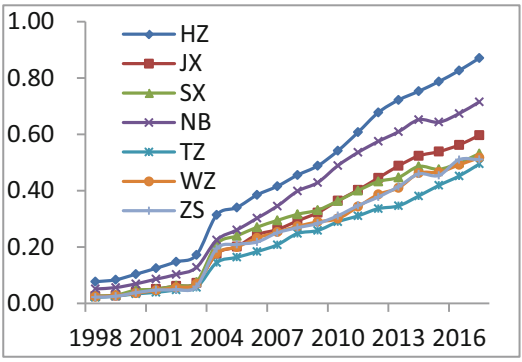

Fig. 2. Score Tendency of Social Economy System

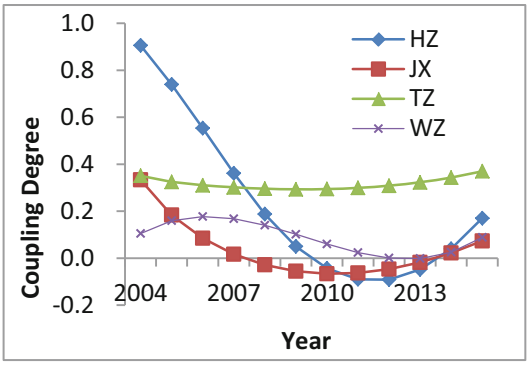

Fig. 3. Tendency of Regeneration Development of Coupling

Table 2. Parameter Results of Social-Economy Development Evaluation

	HZ	JX	SX	NB	TZ	WZ	ZS
a	1.033776	1.223965	0.899794	1.186697	1.122085	1.030853	0.97507
c	0.039586	0.015944	0.036747	0.022542	0.016011	0.023307	0.026845

it was the main part of the curve and be more important for coupling analysis, curves after 2004 were estimated with the following logarithmic equation, transferred from the Gompertz curve.

$$\ln S_2 = \ln c + a \ln t + \varepsilon \tag{4}$$

With the same requirements of parameter tests, parameter estimate results of the seven cities were listed in Table 2.

The coupling angles of reclaimed land utilization and social-economy development should be calculated based on Eq. (4) and Eq. (5), with results listed in Table 3.

Obviously, all the angles varied in the interval of -0.1° to 1° around the axis of V_B, meaning that the coupling effect was mainly for social-economy development effects and the effects of land utilization was in the matching or coordination place. The small even negative values of coupling angle were mainly for the reason of strict reclaim restriction, land utilization efficiency, and ecology reservation in ecology civilization construction. Cities can be classified into three coupling types according to the tendency of angle curves.

Coupling tendencies of those cities of Hangzhou, Jiaxing, Taizhou and Wenzhou went through a process from decline to increase as Fig. 3 shows. It would not be a shot time for new effects observable for whereabouts adjustments in land utilization, but original effects would be weak gradually. This is why the coupling cure of Hangzhou and Jiaxing was decline year by year until 2010, with efforts in reclaimed land utilization efficiency promotion for efficient, ecology and sustainable development. Regeneration coupling curve of Wenzhou was a little bit periodic, with some corresponding policies

Table 3. Historic Coupling Angles of the Seven Costal Cities

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
HZ θ	0.91	0.74	0.55	0.36	0.19	0.05	-0.04	-0.09	-0.09	-0.05	0.04	0.17
JZ θ	0.33	0.18	0.08	0.02	-0.03	-0.06	-0.07	-0.06	-0.05	-0.02	0.02	0.07
SX θ	0.15	0.16	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.19	0.19
NB θ	0.11	0.10	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.17	0.18	0.20
TZ θ	0.35	0.32	0.31	0.30	0.30	0.29	0.29	0.30	0.31	0.32	0.34	0.37
WZ θ	0.10	0.16	0.18	0.17	0.14	0.10	0.06	0.02	0.00	0.00	0.03	0.09
ZS θ	0.01	0.03	0.07	0.12	0.18	0.24	0.31	0.37	0.44	0.49	0.54	0.58

to help it out. The decline range of coupling curve in Taizhou was not too remarkable, so the regeneration speed would not be fast.

Though coupling value of Shaoxing and Ningbo was gradually increasing, the growth was slowing down as Fig. 4 shows. In this extreme development type, it was already coming to the end of the growth curve for original coupling effects being close to its limit. Some strategies should be adopted to help the curve to enter a new pathway from the original curve to a new growth curve with the constraint of limited land, in the framework of ecology civilization construction.

The coupling values of Zhoushan increased in a relatively fast speed in all the seven coastal cities with symbiosis development forms shown in Fig. 5. Compared to the other cities, the start point of coupling curve in Zhoushan was much lower, but the coupling value had be the biggest in all coastal cities after continuous increase over 10 years.

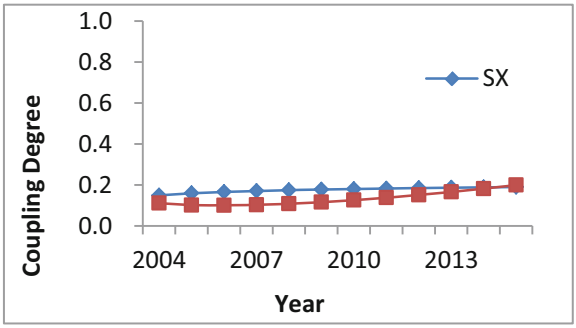

Fig. 4. Tendency of Extreme Development of Coupling

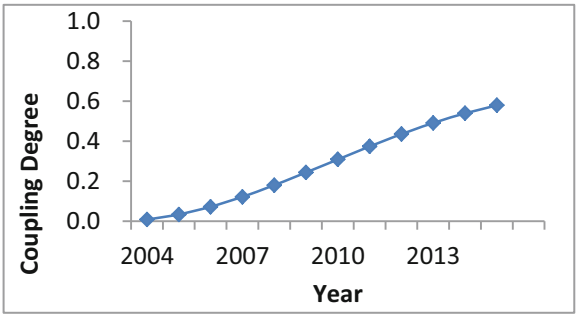

Fig. 5. Tendency of Symbiosis Development of Coupling

5 Conclusions

According to empirical analysis of coastal cities of Zhejiang, there were three main conclusions as follows.

(1) The coupling values of reclaimed land utilization and social-economy development in all coastal cities were low because the growth of land utilization effects was inevitably slow after long time development in a high level. More attention should be paid to promote the coupling degree of reclaimed land utilization and social-economy development.
(2) The coupling of coastal cities of Zhejiang differed much totally in three types. After long time development of reclaimed land, coupling in old pathway was declining and the new pathway of coupling was sprouting in most cities, named regeneration development, especially in Hangzhou. The coupling curve was coming to the end of growth curve in some cities, without any signal of new growth pathway, named extreme development. And the coupling tendency in Zhoushan was in the coordination and symbiosis pathway, named symbiosis development.
(3) Decline of coupling was inevitable, proved by empirical studies above. Firstly, the dynamic coupling state should be recognized clearly by related government managers. And then corresponding strategies should be taken properly and timely to ensure, or promote the dynamic coupling curve of reclaimed land utilization and social-economy development in a high and efficient pathway.

Acknowledgements. This paper is sponsored by Major Humanities and Social Sciences Research Program of Zhejiang Universities, China (Grant No. 2021QN068).

References

1. Q. Biao and F. Chuang-Lin, The dynamic coupling model of the harmonious development between urbanization and eco-environment and its application in arid area. ACTA ECOLOGICA SINICA, 2005. **25**(11): p. 3003-3009.
2. F. Hui, et al., The Coupling Coordination Evaluation between Population Urbanization and Land Urbanization in Zhejiang Province. ECONOMIC GEOGRAPHY, 2014(12): p. 21-28.
3. L. ziyuan, H. yiqing, and M. hua, Coupling relationofship study of financial agglomeration and economic development in East China. Enterprise Economy, 2013(08): p. 135–138.
4. Z. Jing, S. Chaofang, and D. Rongrong, The spatiotemporal evolution of the coupling and coordination of logistics and information industry in the Yangtze River Economic Belt. Hunan Social Sciences, 2019: p. 111–119.
5. L. Lin and Z. Wei-ping, Research on Spatial Heterogeneity of Coupling Coordination Between Scientific and Technological Innovation and Economic Development in China. East China Economic Management, 2019: p. 1–8.
6. Z. Ying and W. Fei, Study on the Evaluation of China Provincial Innovation-Driven Development Based on Coupling Theory. Chinese Journal of Management, 2016. **13**(10): p. 1509-1517.

7. C. Duan-lu, P. Bao-fa, and X. Jian-xin, The Coupling Characteristics of Eco-economic System in Dongting Lake Area. SCIENTIA GEOGRAPHICA SINICA, 2013(11): p. 1338-1346.
8. H. Cao, The Study of the ecology-economic system coupling mechanism in Lake Basin based on Ecological Civilization: A Case Study in Erhai Lake. 2014, Cnki.
9. L. Jin and Z. Hui-min, Empirical Analysis of Coupling Relationship between Human Capital and Economic Growth in Chinese Provinces. The Journal of Quantitative & Technical Economics, 2013(09): p. 3–19+36.
10. G. Nan, et al., Study on the Coordinative Development between Tourism Industry and Urbanization Based on Coupling Model: A Case Study of Xi'an. Tourism Tribune, 2013(01): p. 62-68.