

# Predicted influence of overhead transmission lines on land-use transfer: A case study on landscape and famous scenery

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**Abstract.** Taking Baihetan—Jiangsu  $\pm 800$ kV UHVDC power transmission project as an example, the influence of tower foundation on land-use types and functions were predicted using ArcGIS platform and eCognition Developer. Through the construction of land-use transfer matrix analysis, the change of land-use transfer situation and structure were discussed. Our results showed that the forest transfer intensities ( $R_T$ ) of Tangya River Scenic spot and Three Gorges Scenic area were 0.64 and 1.49 respectively, the  $R_T$  of bushes and grasses in Tangya River Scenic spot and Three Gorges Scenic area were 1.01 and 0.37. The  $R_T$  of forest, bushes and grasses were both not high. The permanent occupation area of project was all transferred into building land, the construction land dynamics degrees ( $K_T$ ) of Tangya River Scenic spot and Three Gorges Scenic area were +0.40% and +0.031% respectively, which were both low. Thus we drew a conclusion that the project construction would have a slight impact on land use pattern and function and would not affect the overall ecological function and structure of landscape and famous scenery.

## 1 Introduction

With the development of economy, electricity consumption, the total load of regional power grid was on the rise. The expansion of power grid planning system can bring obvious social and economic benefits in energy development, industrial layout, load adjustment, system security and economic operation [1]. The future power grid would also realize the optimal allocation of resources by long distance, large capacity and cross-region [2]. Since the overhead transmission line was a linear project, it passed through a wide range of areas, and sometimes it was difficult to avoid the sensitive area completely. Currently, the ecological impact of overhead transmission lines in environmental impact assessment was mainly manifested in the permanent occupation of line base. The permanent occupation would lead to the loss of land use function and the transfer of land-use type in protected area [3].

The dynamic study of land-use and land-cover were a key and urgent subject [4]. In 1995, the International Geosphere and Biosphere Program (IGBP) and the Human Dimension Plan of global environmental change (HDP) jointly proposed a research plan named "Land-use and Land-cover Change (LUCC)". From then on, the study of land use change has become a foreword and hotspot research [5]. The land-use matrix can not only quantitate the structure characteristics of regional land-

use change, but also can predict the direction of land-use type change. Recently, the land-use transfer matrix mainly focused on the net change of land-use type [6], without considering the spatial process and related attributes of the dynamic change. Thus most of study can not depict the spatial process of land-use change completely [7].

In this study, the net change, transfer intensities ( $R_T$ ) and the construction land dynamics degrees ( $K_T$ ) of land-use type were adopted to truly show the spatial process of land-use change [3]. Taking Baihetan—Jiangsu  $\pm 800$ kV UHVDC power transmission project as an example, we predicted the influence of tower foundation on landscape and famous scenery. This project crossed the provincial scenic area of Tangya River and the Three Gorges of the Yangtze River, occupied permanent area in scenic area, which has typical representative.

Baihetan—Jiangsu  $\pm 800$ kV UHVDC power transmission project was selected. This project started from xianfeng converter station in Liangshan prefecture, passed through Sichuang province, Chongqing City, Hubei Province, Anhui Province, Jiangsu Province, and ended at Changshu Nanyushan converter station in Suzhou, involving 5 provinces, 20 cities and 58 districts and counties. The total length of the path was about 2081.9km. Due to long conveying distance, urban planning, terrain

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**Table 1** Details of Project

Project	Landscape and famous scenery	Relative position relation	Evaluation area /hm <sup>2</sup>	Area of landscape and famous scenery /hm <sup>2</sup>	Type of protected area
Baihetan-Jiangsu ±800kV UHVDC power transmission project	Tangya River	Crossed second-level protection 0.9km, Crossed third-level protection 4.7km, a total of 10 bases	about 2507	34910	Mainly to forest ecosystem and farmland ecosystem
	Three Gorges of the Yangtze River	Crossed second-level protection 3.0 km, Crossed third-level protection 1.2 km, a total of 7 bases	about 3171	113300	Mainly to forest ecosystem, farmland ecosystem and wetland ecosystem

(Note: according to the Technical Guidelines for Environmental Impact Assessment on Power Transmission and Transformation Engineering (HJ24-2014), the evaluation area in this study was the belt area within 1000m on both sides outside the ground projection of the conducting wire.)

conditions and other restrictions, the line could not completely avoid sensitive areas, and finally crossed the provincial scenic area of Tangya River and Three Gorges of the Yangtze River in Hubei Province.

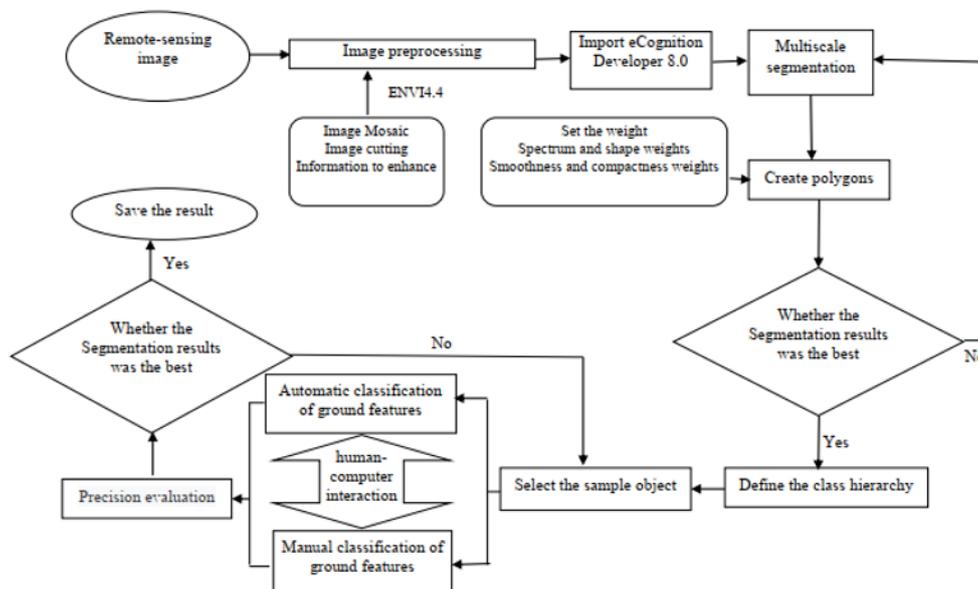
Baihetan—Jiangsu ±800kV UHVDC power transmission project passed through Tangya River for three times, crossed the second-level protection area 0.8 km (without setting tower), the second-level protection area 0.1 km, the third-level protection area 4.7km, setting up a total of 10 bases. On the other hand, this project passed through the Three Gorges of the Yangtze River, crossed the second-level protection area 3.0 km, third-level protection area 1.2 km, also setting up a total of 7 bases. This study selected the area of cross section, estimating the permanent occupation area, constructing the land-use transfer matrix, finally predicting the

influence of landscape and famous scenery on land-use [8]. Details were showed in Table 1.

## 2 Method

### 2.1. Interpretation and calculation of land use types

The high-resolution image was used as the source data and the image was calibrated, spliced and cut by using Arc GIS, then the type of land-use were divided into five categories, which were forest land, bushes and grasses land, cultivated land, water, building and other land [9]. Land-use data within the evaluation area were extracted by the method of human-computer interactive interpretation though eCognition8.0. The technology roadmap was shown in Figure1.



**Figure1.** Extraction and interpretation process of land-use remote sensing information

## 2.2. Calculation and construction of land-use transfer matrix

Interpreted the land-use type data within the evaluation scope, then loaded into ArcGIS to obtain the type of land-use. According to the land-use type and the proposed base of tower in landscape and famous scenery, the land-use change situation after the completion of the project was estimated and the land-use area transfer matrix were constructed. The relevant indexes of land-use transfer were calculated as follows:

$$K_T = (U_b - U_a) / U_a \times 1/T \times 100\% \quad (1)$$

$K_T$  represented a certain land-use dynamic attitude,  $U_a$  and  $U_b$  were the area of a certain land at the beginning and the end of the research respectively.  $T$  was the time of research. When the time was set as year, the value of  $K_T$  was the annual change rate of a certain land-use type.

$$R_T = (\Delta LU_i / LU_i) / (\Delta LU_0 / \Delta LU_0) \quad (2)$$

$R_T$  was the intensity of land-use conversion,  $\Delta LU_i$  was the transferred area of certain  $i$  land,  $LU_i$  was the land area of certain  $i$  land at the initial period.  $\Delta LU_0$  was the total roll-out area of the evaluation area,  $LU_0$  was the total area of the initial evaluation area before the construction.

$K_T$ —the dynamic attitude of a certain land-use type, represented the quantitative change of a certain land-use type within a certain time in the research area, which can describe the speed of land-use change within a certain time, compare the regional difference and predict the trend of land-use change in the future.

$R_T$ —the intensity of land-use conversion, can describe the multiple relation between the conversion rate of certain land type and the whole land conversion rate quantitatively, compare the regional difference of land-use change, analyze and predict the dynamic structure of land-use transfer within a certain time. When the  $R_T > 1$ , it indicated that the roll-out intensity of a certain type was higher than that of whole evaluation area, otherwise, the roll-out intensity was lower than the overall roll-out

intensity. When the  $R_T > 5$ , it was believed that the transfer intensity of a certain type land was significantly higher than that of the whole evaluation area [10-12].

## 3 Results

### 3.1. Land-use transfer matrix of Tangya River Scenic spot

The land-use transfer matrix result of Tangya River was shown in Table 2. The project was intended to occupy an area of 0.34 hm<sup>2</sup> permanently. Results showed that the land-use type of evaluation area in Tangya River Scenic spot were mainly forest land and cultivated land. The project was intend to occupy the forest, bushes and grasses land and cultivated land, with an area of 0.14hm<sup>2</sup>, 0.09hm<sup>2</sup> and 0.11hm<sup>2</sup> respectively. Then the permanent occupation area was all transferred to the building land. Thus, the building and other land within the Tangya River Scenic spot evaluation scope would increase by 0.34 hm<sup>2</sup> in total after the completion of project.

It can be seen from Table 2 that the land-use type of crossing section in Tangya River was mainly forest land, accounting for 64.09% of the whole evaluation section, indicating that the ecological environment of the crossing section was optimistic. From the perspective of transfer intensity, the transfer intensity of bushes and grasses land and cultivated land were both higher than 1, indicating that the transfer intensity of bushes and grasses land and cultivated land were both greater than that of the whole evaluation area. From the perspective of dynamic attitude of a certain land-use type, the land-use transfer matrix shown that the dynamic change of forest land, bushes and grasses land, cultivated land were all not large, and the biggest change was happened in building land ( $K_T=0.40\%$ ), which may be due to the newly transferred land-use types of the project were all changed into building land, leading to a huge dynamic change of building and other land finally.

**Table 2** Land-use transfer matrix of Tangya River scenic spot Unit:hm<sup>2</sup>

Type of land-use	Forestland	Bushes and grasses	Cultivated land	Water	Building and other land	Total	Percent /%	Roll out	$R_T$
Forestland	1606.92	0	0	0	0.14	1607.06	64.09	0.14	0.64
Bushes and grasses	0	657.51	0	0	0.09	657.60	26.23	0.09	1.01*
Cultivated land	0	0	135.70	0	0.11	135.81	5.41	0.11	5.98*
Water	0	0	0	22.66	0	22.66	0.90	0	0
Building and other land	0	0	0	0	84.19	84.19	3.36	0	0
Total	1606.92	657.51	135.70	22.66	84.52	2507.32	100	0.34	/
Percent/%	64.09	26.22	5.41	0.90	3.37	100	/	/	/

Type of land-use	Forestland	Bushes and grasses	Cultivated land	Water	Building and other land	Total	Percent /%	Roll out	$R_T$
Roll in	0.14	0.09	0.11	0	0.34	/	/	/	/
Net change in area	-0.14	-0.09	-0.11	0	+0.34	/	/	/	/
$K_T$ /%	-0.009	-0.014	-0.081	0	0.40	/	/	/	/

(Note: \* indicated that the transfer intensity of a certain type land was greater than that of total land-use.)

### 3.2. Land-use transfer matrix of Three Gorges Scenic spot

The results of land-use transfer matrix in the Three Gorges Scenic were shown in Table 3. The project was intended to occupy an area of 0.22 hm<sup>2</sup> permanently, the land-use types of evaluation area in Three Gorges Scenic were mainly forest land, Bushes and grasses, cultivated land. The project was intend to occupy the forest, bushes and grasses land, cultivated land permanently, with an area of 0.08hm<sup>2</sup>, 0.02hm<sup>2</sup> and 0.12hm<sup>2</sup> respectively. The permanent occupied area was all transferred to the building land. Thus, the land-use type of building and other land within the Three Gorges Scenic evaluation scope would increase by 0.22 hm<sup>2</sup> in total after the completion of project.

It can be seen from Table 3 that the proportion of forestland, Bushes and grasses, cultivated land and

building and other land in the crossing section of Three Gorges Scenic were quite, which indicated that there was a large human disturbance in the section. From the perspective of transfer intensity, the transfer intensity of forestland and cultivated land were both higher than 1, indicating that the transfer intensity of forestland and cultivated land were both greater than that of the whole evaluation area. From the perspective of dynamic attitude of a certain land-use type, the land-use transfer matrix shown that the dynamic change of forest land, bushes and grasses land, cultivated land were all not high, which were all lower than the dynamic change of building land ( $K_T=0.031\%$ ). This may be due to the fact that all the newly transferred land types have been converted into building land, and the initial area of the building land within the area of evaluation was very small, which lead to a relatively large dynamic change of building land eventually.

**Table 3** Land-use transfer matrix of Three Gorges Scenic spot Unit:hm<sup>2</sup>

Type of land-use	Forestland	Bushes and grasses	Cultivated land	water	Building and other land	Total	Percent /%	Roll out	$R_T$
Forestland	773.26	0	0	0	0.08	773.34	24.39	0.08	1.49*
Bushes and grasses	0	768.81	0	0	0.02	768.83	24.25	0.02	0.37
Cultivated land	0	0	780.06	0	0.12	780.18	24.60	0.12	2.22*
water	0	0	0	149.58	0	149.58	4.71	0	0
Building and other land	0	0	0	0	699.13	699.13	22.05	0	0
Total	773.26	768.81	780.06	149.58	699.35	3171.07	100	0.22	/
Percent /%	24.28	24.24	24.60	4.72	22.05	100	/	/	/
Roll in	0.08	0.02	0.12	0	0.22	/	/	/	/
Net change in area	-0.08	-0.02	-0.12	0	+0.22	/	/	/	/
$K_T$ /%	-0.010	-0.003	-0.015	0	0.031	/	/	/	/

(Note: \* indicated that the transfer intensity of a certain type land was greater than that of total land-use.)

### 4. Discussion

To sum up, we estimated that the project would have little influence on building land after completion. The dynamic attitude  $K_T$  of a certain land-use type can predict the tendency of land-use change in the future. The

permanent occupation land of overhead transmission line would be converted to building land, thus it was expected that the project would have the greatest impact on building land. The results of the land-use transfer matrix showed that the dynamic attitude  $K_T$  of building land-use in Tangya Rive Scenic and the Three Gorges Scenic Spot were 0.40% and 0.031% respectively, which were both

low. The evaluation of the Three Gorges Scenic spot was larger, resulting in a lower  $K_T$ . Therefore, we predicted that the project would have little influence on the change of the proportion of building land after completion.

Among all the land-use types in the crossing section, it was estimated that the conversion intensity of cultivated land would be the largest. The results of the land-use transfer matrix showed that the cultivated land transfer intensity  $R_T$  in Tangya Rive Scenic and the Three Gorges Scenic Spot was 5.98 and 2.22 respectively. The cultivated land transfer intensity values in both Tangya Rive Scenic and the three Gorges Scenic Spot were higher than 1, indicating that the cultivated land transfer intensities of the crossing section were much greater than that of the whole evaluation area. The intensity of cultivated land transfer in Tangya River scenic area was higher than 5 ( $R_T > 5$ ), which indicated that the conversion intensity of cultivated land was significantly larger than that of the whole evaluation area. This may be due to the small initial area of cultivated land. The conversion intensity  $R_T$  can quantitatively describe the multiple relationship between the conversion rate of a certain land type and the overall conversion rate, compare and analyze the regional differences of land use change. The larger the area occupied by the project, the smaller the initial area of a certain type land was, then the larger conversion intensity of a certain type land.

It was predicted that the project would have a slight effected on the land-use pattern and function of the evaluation area and the whole Scenic Spot. The overall ecological function and structure of the evaluation area and the whole Scenic Spot would not be affected. The permanent occupation area of overhead transmission line was mainly the cement hardening area of the four tower legs, which occupies a small permanent area. The results of land-use transfer matrix showed that the dynamic attitude of the project area to each land type were all small ( $K_T \leq 0.40\%$ ), so we drew a conclusion that the construction of the project would not change the original land use pattern in the evaluation area.

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