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THE IMPACT OF HUMAN FACTORS ON THE CHANGE IN VEGETATION COVER OF THE BE RIVER BASIN IN THE PERIOD FROM 2000 TO 2015

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ABSTRACT

The Be river basin is located in the area with a rapid urbanization rate and a large immigrants proportion annually. Therefore, the population growth rate for the period from 2000 to 2015 in the river basin is up 3,53% which is 3,27 times as high as the population growth rate of Vietnam. These are the major causes leading to the fluctuation in vegetation cover of the Be river basin during over time. This research used methodologies including data collection, statistical analysis, mapping method and geographic information system to evaluate the impact of human factors to the vegetation cover fluctuation of the Be river basin in the period from 2000 to 2015. Based on the results of change map in the vegetation cover, a research group set up fluctuating matrix, analyze to clarify the vegetation coverfluctuation situation due to human's impacts in the Be river basin in the period from 2000 to 2015.

Keywords: the change, vegetation cover, the Be river basin, human factor.

TÓM TẮT

Tác động của nhân tố nhân sinh đến biến động lớp phủ bề mặt lưu vực sông Bé giai đoạn 2000 – 2015

Lưu vực sông Bé nằm trong vùng có tốc độ đô thị hóa nhanh, lượng dân nhập cư hàng năm lớn, do đó tỉ lệ tăng dân số ở lưu vực giai đoạn 2000 – 2015 lên đến 3,53% gấp 3,27 lần so với cả nước. Đây là những nguyên nhân chính dẫn đến biến động lớp phủ bề mặt lưu vực sông Bé trong thời gian vừa qua. Nghiên cứu này sử dụng phương pháp thu thập, phân tích, xử lí tư liệu và phương pháp bản đồ, hệ thống thông tin địa lí đánh giá tác động của nhân tố nhân sinh đến biến động lớp phủ bề mặt lưu vực sông Bé giai đoạn 2000 – 2015. Dựa trên kết quả bản đồ biến động lớp phủ bề mặt, nhóm nghiên cứu lập ma trận biến động, phân tích làm rõ hiện trạng biến động lớp phủ bề mặt do tác động của con người ở lưu vực sông Bé giai đoạn 2000 – 2015.

Từ khóa: biến động, lớp phủ bề mặt, lưu vực sông Bé, nhân tố nhân sinh.

1. Introduction

The Be river basin belongs to the provinces such as Binh Duong, Binh Phuoc, Dong Nai and Dak Nong of Vietnam. Most of the basin area is located in the South East, an area with high economic growth rate in Vietnam, so, this attracted large numbers of immigrants

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every year, In the period from 2000 to 2015, the immigration rate is 32,46‰, which is 4,29 times as high as immigration rate in Vietnam in the same period [1]. The highly increase of mechanical population makes the population growth rate in the basin in the period from 2000 to 2015 up to 3,53%, which is 3,27 times as high as that of Vietnam [1]. The high immigration rate and high population growth rate are the main reasons leading to the expansion of the production and living areas of people, causing a lot of changes to the vegetation cover of the Be river basin in the last time. In addition, the Be river basin is also the residential area of ethnical minorities with low educational level, creating many difficulties in management of the change in vegetation cover. Therefore, the analysis to clarify the vegetation cover fluctuation situation in vegetation cover in the Be river basin under the influence of human factors will help policy makers to find out solutions to adjust the change in vegetation cover in the positive direction, to exploit and protect the resources in a sustainable way.

In recent years the strong development of information technology has helped the researches on the change in vegetation cover more quickly and accurately. In addition, research on the change in vegetation cover in river basins contributes to the effective exploitation integrity's protection of natural components. In this article, the authors applied GIS (Geographic Information System) to develop a map of the change of vegetation of the Be river basin in a period from 2000 to 2015, and based on that to clarify the current situation and find out the human factors that affect the change of vegetation in the research area.

2. Background of the Study

Tran Tuan Tu (2011) calculated the vegetation index and the vegetation cover coefficient to quantify the potential erosion of the Be River Basin [2]. However, this study only classified the vegetation cover to determine the vegetation index and the vegetation cover coefficients. It didn't analyze the change in vegetation cover. In addition, the impact of human factors is not considered as a parameter in determining potential erosion

Nguyen Truong Ngan (2011) based on the factors affecting soil erosion that are proposed by R. P. C. Morgan, 2005, used the Analytic hierarchy process AHP (Thomas L. Saata, 1970) to determine the weights for soil erosion factors [3]. The author identified four main factors affecting the erosion of the Be river basin: slope, coverage, rainfall intensity and slope length. In this study, vegetation cover was identified as one of the four factors causing soil erosion, the weight was determined by human activity.

Nguyen Duy Liem (2011) integrated the SWAT model and GIS technology to simulate the flow in the Be River basin from the digital elevation data (DEM), current land use, soil and weather [4]. By that, this study assessed the change of flow as well as found the flow rule in the basin. In this study, natural factors were used as input data to establish a flow model while human factor was not mentioned.

In the comprehensive report on Irrigation Planning of the Be River Basin of The Southern Irrigation Planning Institute (2012) the current situation was generalized [5]. However, the change of the vegetation cover in the basin and causes were not analyzed.

Nguyen Dan Tinh (2016) based on 4 indicators including the pressure of water source, the pressure of extraction and use, ecosystem and management capacity to assess vulnerability of surface water sources in Be river basin - territory of Binh Phuoc province [6]. Vegetation cover was mentioned in the ecosystem index by current forest situation.

In summary, these researches were mainly focused on assessing the natural factors of the Be river basin. There is no research analyzing human impacts on natural components in this basin. Therefore, studying on the impact of human activities on the change in the vegetation cover of the Be river basin in the period from 2000 to 2015 is a new research direction.

3. Methods

3.1. Methods of data collection, analysis and processing

Documentation system related to changes in vegetation cover of the Be river basin is grouped by content. After that, the impacts of human activities on the change in vegetation cover of the Be river basin are selected and analyzed.

3.2. Methods of mapping and geographic information system

Geographic information systems and maps are the main methodologies of this research. The research process is implemented through the following steps:

- *Data digitization*: Data on vegetation cover of 1/100.000 scale in 2000 and 1/50.000 scale in 2015 on different map fragments are digitized, converted to the same scale of 1/250.000, to develop a map of the current vegetation cover situation of the Be river basin in 2000 and 2015.
- *Code for each type of vegetation cover*: Each type of vegetation cover is fitted with a corresponding code (Table 1).

Table 1. *Code of vegetation cover in 2000 and in 2015*

Year / Type of vegetation cover	2000	2015
Broadleaf forest (BF)	1	1
Coniferous forest (CF)	2	2
Mixed forest (MF)	3	3
Shrub, grassland (SG)	4	4
Wet rice, secondary crops (WRSC)	5	5
Short-term industrial crops (STIC)	6	6
Long-term industrial crops (LTIC)	7	7
Cultivated plants in residential areas (CPIRA)	8	8
Vacant land, uncovered hill (VLUH)	9	9
River, spring, lake (RSL)	10	10

- *Mapping and analysis of the change in vegetation cover*: Using the spatial analysis function of ArcGIS software, the overlay method of current vegetation cover map in 2000 and 2015. As a result, a map of the change in vegetation cover of the Be river basin was developed, in period from 2000 to 2015. Map attribute data is converted to Excel software to calculate the area of change in vegetation cover.

4. Findings and discussion

4.1. The current situation of vegetation cover of the Be river basin in the period from 2000 to 2015

According to the Southern Irrigation Planning Institute (2000) and Center of Survey and Mapping data which is affiliated to The Department of Survey and Mapping of Vietnam (2015), the current vegetation cover situation of the Be river basin includes 10 different types and is divided into 3 groups: Group of natural vegetation: Broadleaf forest, coniferous forest, mixed forest, shrub and grassland. Group of cultivated vegetation: Wet rice, secondary crops, short-term industrial crops, long-term industrial crops, cultivated plants in residential areas. Group of other vegetation cover: Vacant land, uncovered hill, river, spring, lake.

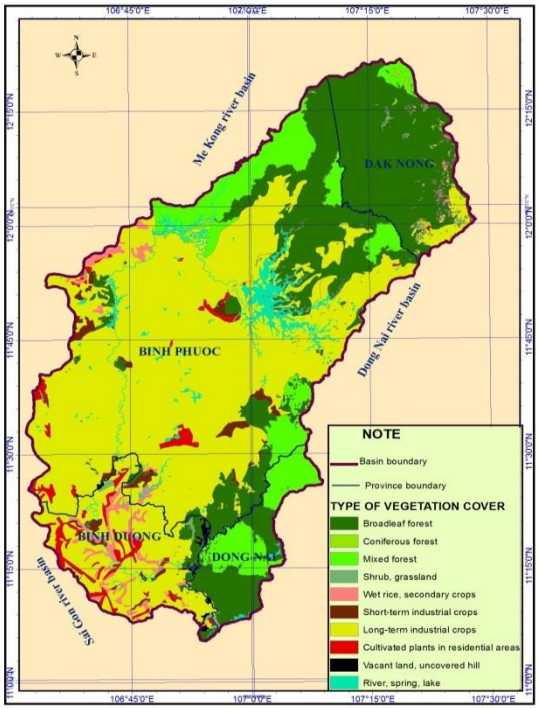

Figure 1. *The current vegetation cover map of the Be river basin in 2000 is scaled from the 1/100.000 scale*

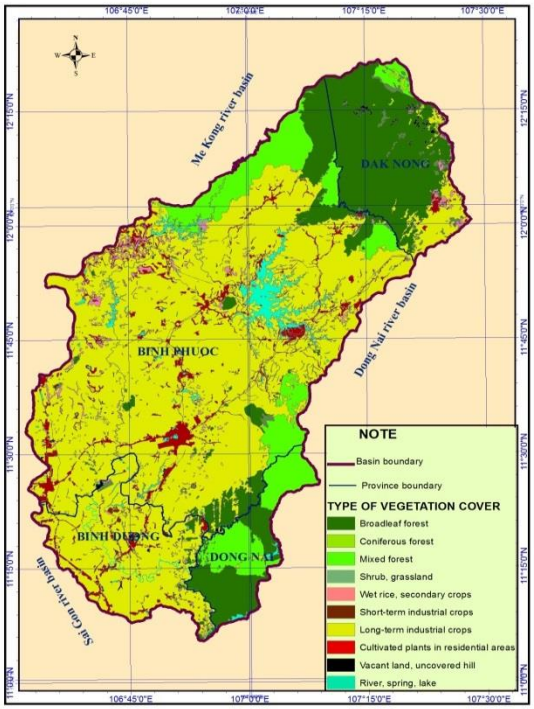

Figure 2. *The current vegetation cover map of the Be river basin in 2015 is scaled from the 1/50.000 scale*

Based on the attribute data of the current vegetation cover map of the Be river basin in 2000 and 2015, the study calculated the area and ratio of all types of vegetation cover as shown in Table 2.

Table 2. *The current vegetation cover map of the Be River basin in 2000 and 2015*

Types of vegetation cover	**In 2000**		**In 2015**	
Group of natural vegetation cover	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)
Broadleaf forest	202.969	27,11	137.007	18,30
Coniferous forest	1.103	0,15	985	0,13
Mixed forest	81.398	10,87	76.764	10,25
Shrub, grassland	3.222	0,43	6.953	0,93
Group of cultivated vegetation cover				
Wet rice, secondary crops	14.501	1,94	9.385	1,25
Short-term industrial crops	11.048	1,48	571	0,08
Long-term industrial crops	397.346	53,08	451.086	60,26
Cultivated plants in residential areas	16.445	2,20	40.677	5,43
Group of other vegetation cover				
Vacant land, uncovered hill	2.187	0,29	3.667	0,49
River, spring, lake	18.381	2,46	21.505	2,87
Total	**748.600**	**100**	**748.600**	**100**

In 2000, group of natural vegetation cover occupies the largest area with 439.340 ha, equivalent to 58,69% of the basin area. In there, the vegetation cover by long-term industrial crops occupies the largest area with 397.346 ha (53,08%). Group of natural vegetation cover also occupies the large area with 288.692 ha (38,56%). In there, type of the vegetation cover by broadleaf forest occupies the largest area with 202.969 ha (27,11%).

In 2015, vegetation cover in the basin has great change, group of cultivated vegetation occupies a large area with 502.719 ha (67,15%). Other vegetation cover groups have also changed in area and ratio compared to 2000, the changes are shown in Table 2.

4.2. Mapping and matrices on the change in vegetation cover

In order to clarify the current situation and origin of the change in vegetation cover for the period from 2000 to 2015 by the impact of human factors, the study has coded the type of vegetation cover, overlapped the change maps in current vegetation cover situation in 2000 and in 2015 on ArcGIS software. Based on result of the map overlapping process, we can develop a map of the change in vegetation cover of the Be river basin in the period from 2000 to 2015 as shown in Figure 3 (in which the same codes as 11, 22… 1010 are the unchanged vegetation cover, the remaining codes as 12, 13.109 are the changed vegetation cover. Example: code of 12 is broadleaf forest that is changed to coniferous forest.

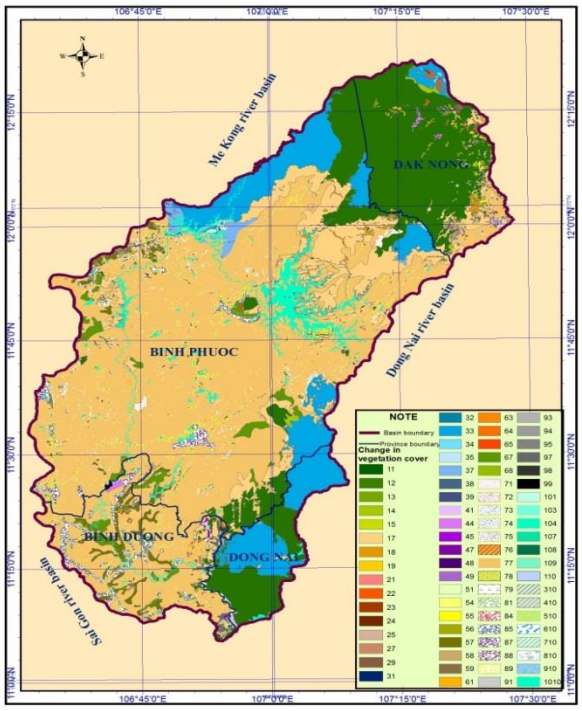

Figure 3. *The map of the change in vegetation cover of the Be river basin in the period from 2000 to 2015 is converted from the scale of 1/250.000*

Based on the change map in the vegetation cover of the Be River basin in the period from 2000 to 2015, developing data field for the changed area, converting the attribute data sheet to Excel and use the PivotTable tool to set up the change matrix in vegetation cover in 2000 and 2015 as shown in Table 3.

Table 3. *Matrix change of vegetation cover of the Be river basin in periodic from 2000 to 2015*

(Unit: ha)

Code 2**000** / Code **2015**	1	2	3	4	5	6	7	8	9	10	**Total in 2015**
1	**132.050**	44	72	677	516	68	2959	29	592	0	**137.007**
2	140	**828**	1				16				**985**
3	116	45	**75.356**			52	1077		118	0	**76.764**
4	2579	87	469	**1428**	150	71	2123	0	2	44	**6953**
5	620	0	183	57	**1461**	0	6897	147	20		**9385**
6					160	**231**	180				**571**
7	61.020	58	5218	832	10.636	10155	**356.200**	5908	1059	0	**451.086**
8	2418		99	1	1388	441	26.914	**9213**	203	0	**40.677**
9	1205	41	0	72	115		912	135	**187**	0	**3667**
10	2821		0	155	75	30	68	13	6	**18.337**	**21.505**
Total 2000	**202.969**	**1103**	**81.398**	**3222**	**14.501**	**11048**	**397.346**	**16.445**	**2187**	**18.381**	**748.600**

4.3. The impact of human factors on the change in vegetation cover of the Be river basin in the period from 2000 to 2015

- *The process of expanding the production of arable farming*: The Be river basin has favorable natural conditions for the development of industrial crops, especially long-term industrial crops such as rubber, cashew, pepper, coffee and so on. This is also the strength of the agricultural sector in this area. Therefore, the area of long-term industrial crops has increased from 397.346 ha (in 2000) to 451.086 ha (in 2015), an increase of 53.740 ha. The increase in the area of long-term industrial crops has strongly impacted on the natural vegetation cover, which reduced the coverage of broadleaved forest, coniferous forest and mixed forest, especially broadleaved forest was changed to long-term industrial crops to 61.020 ha, most of the changed forest area is upstream. The total area of natural vegetation cover was changed to long-term industrial crops up to 67.128 ha in the period from 2000 to 2015. In addition, the area of vegetation cover in long-term industrial crop was increased because of the change in crops of households and individuals from land for annual crop (corn-land, crop-land, short-term industrial crops land) to land for long-term industrial crops with the higher economic value (rubber, cashew, pepper, coffee...). The encroachment of long-term industrial crops cover for other types of cover is shown in Figure 4.

- *The expansion process of agglomerations:* More than 90% of the basin area is located in the South East - the area with high urbanization of Vietnam, the cultivated vegetation cover in the residential area increased in the period from 2000 to 2015, with the growth rate 3,8% per year, from 16.445 ha (2000) to 40.677 ha (2015). The expansion of the agglomerations has impacted and encroached 9/10 types of vegetation cover in the research area. In there, the highest decrease was the long-term industrial crops (26.914 ha), wet rice (1.388 ha), broadleaved forest (2.418 ha), short-term industrial crops (441 ha). We can clearly see this change in Figure 5. More alarmingly, up to 2015 many new residential areas and agricultural areas have encroached on natural forests area, potentially threatening the loss of natural forests in the future (Figure 2).

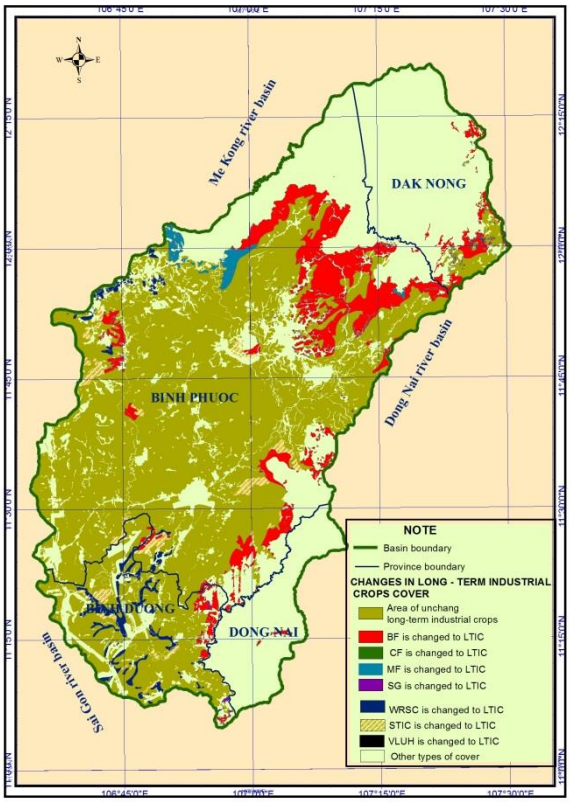

Figure 4. *The map of changes in long-term industrial crops cover of the Be river basin in the period from 2000 to 2015 is scaled from the scale of 1/250.000*

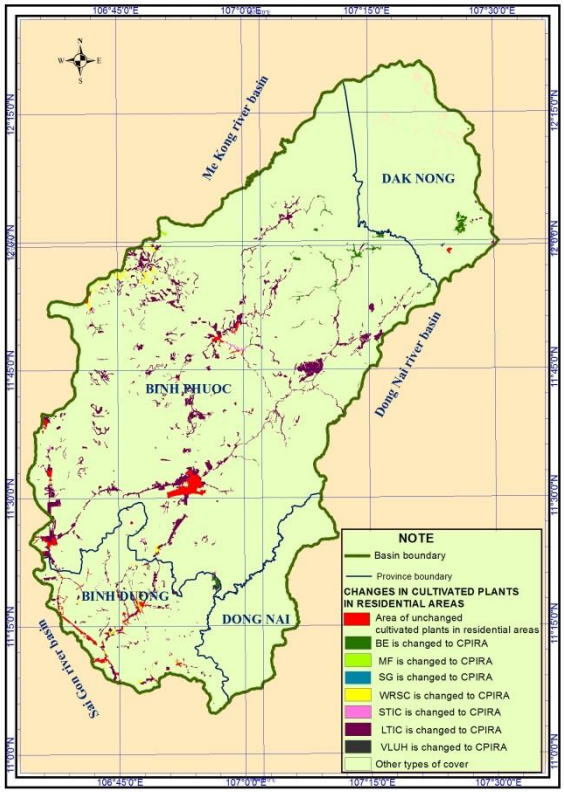

Figure 5. *The map of changes in cultivated vegetation cover in the residential area of the Be river basin in the period from 2000 is scaled from the scale of 1/250.000*

- *Free migration, deforestation for cultivation:* Every year, more than 5000 migrant workers move to the basin, unmanaged migrant workers created a great pressure on natural vegetation cover and other vegetation covers [5]. In addition, deforestation for cultivation in the basin still exists. It's difficult to control this situation because the basin is residence area of many ethnic minorities such as S'Tieng, KheMe, M'Nong, Tay, Nung..., about 20% of the population with the low education level, 75% of the population have not finished secondary and high school [5]. The primitive forest in Bu Dang was almost completely destroyed and changed to land for long-term industrial crops, the primary ecosystem was changed to agro-ecological system on sloping land. Deforestation, industrial crops and unreasonable farming are the causes of soil erosion in recent times [2].

The above analysis shows that the expansion of production activities of the cultivation sector, free migration, deforestation for cultivation and expansion of agglomerations have strongly impacted the natural vegetation cover group on the negative trend, the coverage rate of natural vegetation in the basin has been decreasing. In 2000, the coverage rate of natural vegetation was 38,5% (288.962 ha), up to 2015, only 29,6%

(221.709 ha). Vegetation cover in broadleaved forest was reduced with the highest rate, the period from 2000 to 2015 the area of broadleaf forest was reduced to 65.692 ha, the average reduction rate was 4,9% per year. Up to 2015, the area of unchanged broadleaved forest cover was 132.050 ha, the remaining area was changed to other types of cover such as coniferous forest; mixed forest; shrub, grassland; wet rice, secondary crops; long-term industrial crops; cultivated plants in residential areas; vacant land, uncovered hill, river, spring, lake. Coniferous forest and mixed forest were decreased 118 ha and 4.634 ha. These two types of vegetation cover are mainly changed to cover in shrubs, grasslands and long-term industrial crops (Figure 6).

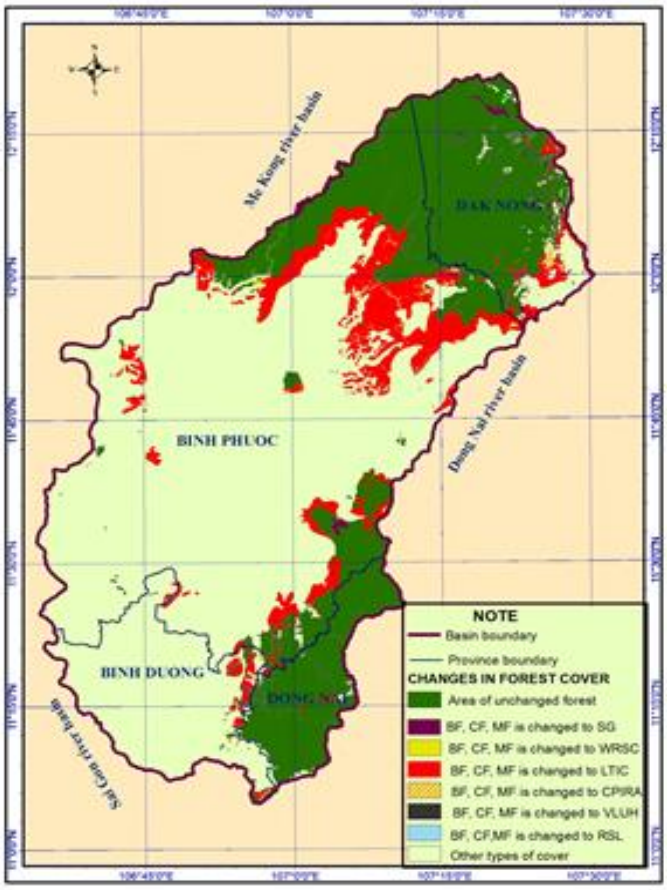

Figure 6. *The map of changes in forest cover of the Be river basin in the period from 2000 to 2015 is scaled from the rate of 1 /250.000*

In addition, the quality of natural vegetation cover is also decreasing. That is the increase of vegetation cover in shrub, grassland at 3,1% per year, from 3222 ha (2000) to 6953 ha (2015). Most of the additional area of this vegetation cover is changed from broadleaved and mixed forest. The reduction in natural forest cover, especially in watershed encroachments, can cause ecological imbalances in the river basin, natural hazards such as landslides, flash floods, soil erosion.

5. Conclusions

The study has developed a map of change in vegetation cover of the Be river basin in periodic from 2000 to 2015, based on that to clarify the current situation of the change in vegetation cover by human factors. These results contribute to provide accurate information on current vegetation cover situation, human impacts on vegetation cover in the Be river basin in period from 2000 to 2015 that helps policy makers to develop solutions to adjust the change in vegetation cover in a positive direction.

These results demonstrate the application of geographic information systems in the research of the change in vegetation cover, which is highly effective and suitable for the characteristics of the Be river basin and other river basins. However, if combined with the remote sensing method in this research, the results will have higher scientific and practical value. Thus, the development direction of this research is the application of remote sensing and geographic information systems to assess the impact of human activity on the change in vegetation cover to make forecasting more reality.

❖ ***Conflict of Interest:*** *Authors have no conflict of interest to declare.*

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