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Conference Paper

Prediction Model of Land Cover Changes using the Cellular Automata – Markov Chain Affected by the BOCIMI Toll Road in Sukabumi Regency

Inne Audina Irawan, S. Supriatna, M.D.M. Manessa, and Y. Ristya

Department of Geography, Faculty of Mathematic and Natural Sciences, Universitas Indonesia

Abstract

The development of a city is a manifestation of regional development. The impact of the development of a city is the occurrence of land cover changes and increase of the settlement areas. In 2002-2018 the vegetation land cover experienced a drastic decline and experienced land conversion into the settlement areas so that the area of settlement land cover increased. This study aims to analyze the spatial patterns of settlement land cover changes that are affected by the existence of BOCIMI Toll road in the Sukabumi Regency, West Java using the Cellular Automata - Markov Chain (CA-MC) method, and modeling for 2032 based on the driving factor (driving factor) applied to the model. CAMC is a simple model of a spatially distributed process in a Geographic Information System (GIS). Five variables used as driving factors, elevation, slope, distance from the river, distance from the road, distance from the toll gates and distance from the toll road. The results of the model show that there are some changes in land cover and an increase of the settlement area that is affected by the physical and infrastructure factors in Sukabumi Regency, it can be seen that the kappa value is 0.8352 or 83.52%. Further, it is necessary to analyze the Sukabumi Regency model and the Regional Spatial Plan (RTRW) to see the growth and direction of the settlement area in Sukabumi Regency.

Keywords: Land cover changes, settlement, BOCIMI TOL Road, Cellular Automata -- Markov Chain

Corresponding Author:
Inne Audina Irawan
inne.audina@ui.ac.id

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1. Introduction

In 2000 there was 2,075,141 population in Sukabumi Regency, then sharply increased in 2012 to 2,393,191 population (BPS Sukabumi Regency, 2018) [1]. In 2015, it noted that the Sukabumi Regency had an income of Rp. 3,212,191,950, - then increased in 2016 amounting to Rp. 3,404,491,216, -, and continues to increase in 2017 to 3,480,485,949, (BPS Sukabumi Regency, 2018) [1]. The settlement area in 2002 covering an area of 8,759 Ha increased in 2010 and 2018 to 11,780 Ha and 13,584 Ha (data processing

in 2018). This fact shows the development in Sukabumi Regency, which continues to increase from year to year and shows a change in land cover in Sukabumi Regency.

To support the development of Sukabumi Regency, the Regional Regulation Number 22 of 2012 concerning the Spatial Planning for Sukabumi Regency in 2012-2032 was drawn up. One of the applications of this RTRW was the construction of the BOCIMI Toll Road which passed through Sukabumi Regency [2]. The issue of BOCIMI Toll development has begun to exist since 1997. However, the launching or groundbreaking has only been carried out in 2011 because shareholders continued to change groundbreaking back in 2014 and the last 2015 finally the shares were fully acquired by PT Waskita Toll Road and construction began in 2016. The presence of the 54 km Bogor Ciawi Sukabumi Toll Road (BOCIMI) could be an alternative route to southern West Java. Construction of the BOCIMI Toll is divided into four sections, namely:

a. Section I, Ciawi - Cigombong: 15.3 km

b. Section II, Cigombong - Cibadak: 11.9 km

c. Section III, Cibadak -- West Sukabumi: 13.7 km

d. Section IV, Sukabumi Barat -- East Sukabumi: 13 km

One model of spatial dynamics to analyze land cover changes in an area is the Cellular Automata (CA) method. Cellular Automata is a simple model of a spatially distributed process in GIS. Data consists of an arrangement of cells (grid), and each is arranged in such a way that it is only allowed to be in one of several conditions.

Of course, the existence of this BOCIMI Toll Road greatly influences changes in land cover around it. The toll road will increase human activity around it and will affect the function of the surrounding land cover. With the various improvements shown by Sukabumi Regency, it is necessary to predict land cover in the future to find out how land cover conditions after the construction of the BOCIMI Toll Road are completed and the Sukabumi Regency RTRW is implemented, or in 2032. With the development of the Sukabumi Regency, it is expected to attract investors to invest in Sukabumi Regency in various sectors. This will be facilitated by predicting land cover in the future.

This study aims to analyze the spatial pattern of changes in land cover in Sukabumi Regency in 2002 - 2018 and Analyze changes in land cover based on the 2032 year model, because of the policy variable using the Regional Spatial Plan (RTRW) in Sukabumi Regency in 2012-2032.

2. Method

This study using four variables, namely physical conditions, infrastructure, land cover, and policy. Each variable has an indicator. Physical conditions consist of the slope, altitude, and distance from the river, as well as infrastructure consisting of distance from the road, distance from the settlement, and distance from the highway which is then used as Driving Factors. Whereas land-use variables use indicators of land-use change in 2002, 2010 and 2018. Moreover, for policy variables using the Regional Spatial Plan (RTRW).

Driving Factors is the data that is used as a regulator of the running of the simulation or the model. Land cover variables function as determinants of land cover change patterns, while policy variables are used as scenarios (RTRW scenarios), limits, and as selectors of results from models that use free scenarios.

Data collection is done twice, namely secondary data collection and primary data collection --- the secondary data obtained from the relevant agencies that have the data. Then the data is collected for further processing. The image used in this study is a download from USGS, which is a Landsat image with a resolution of 30 x 30 meters per pixel unit. The downloaded image consists of four images at different times but still in the same location (to see temporal changes in Sukabumi District). The image Sukabumi Regency at the located is an image on path 122 and row 65 and the type of image used is Landsat 8 OLI image and Landsat 7 ETM + image. The image used is the image in 2002, 2010 and 2018.

The primary data collected in this study consisted of documentation data and data points for plotting field validation. The documentation in this study is documentation in the form of pictures/ photos taken from the field. Plotting points are taken by plotting in the field using the Avenza Maps application that installed in mobile devices. And the validation of the land cover map using the Kappa Accuracy method.

Modeling process performed using on the Idrisi Selva 17 application where the modeling process requires the ability to use Land Change Modeller (LCM) tools. The process is carried out by running the Markov Chains process and entering driving factors in raster format into the Idrisi Selva 17 application. After that, the model accuracy test is performed using the K-Standard (Kappa Coefficient) in the ENVI 5.1 application until the value reaches> 70% or passes the test accuracy.

3. Result

Land cover in Sukabumi Regency in 2002 dominated by non-forest vegetation, which was 88,446.9 Ha. The least land cover is water area, of 81.22 Ha. Settlement area land cover has an area of 8,758.73 Ha. Land cover in Sukabumi Regency in 2010 was dominated by non-forest vegetation, which was 85,939.2 ha. The least land cover is water area of 50.5 ha. Settlement area land cover has an area of 11,780.4 Ha. Land cover in Sukabumi Regency in 2018 is dominated by non-forest vegetation, which is an area of 84,260.2 hectares. The least land cover is a water area of 44.71 ha. Settlement area land cover has an area of 13,584.5 Ha. Changes and land cover area of Sukabumi Regency in 2002, 2010, and 2018 shown in table 1.

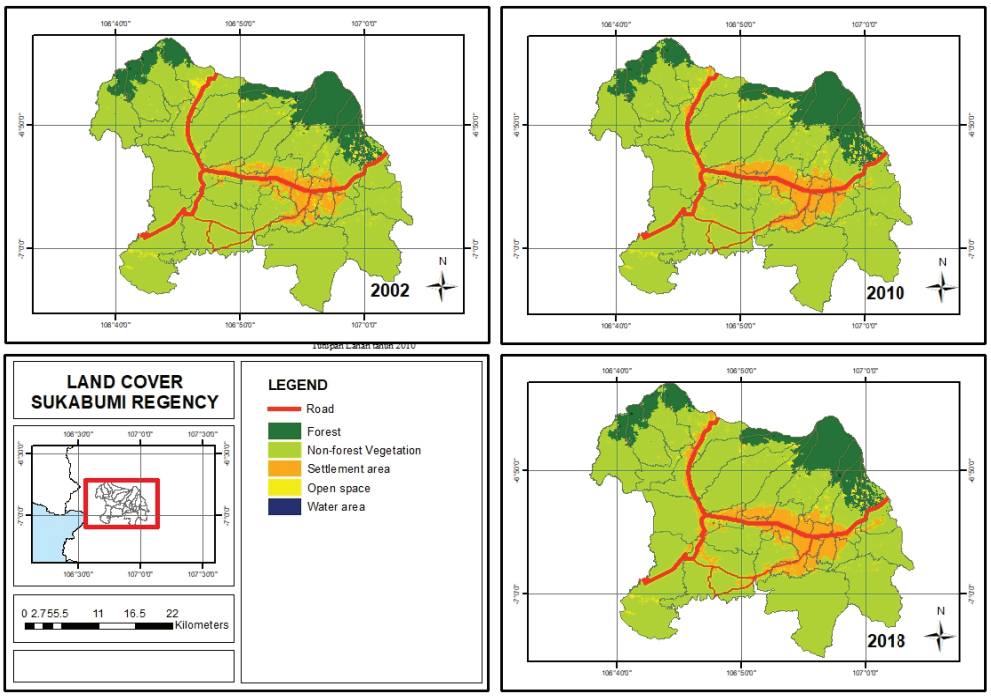

Figure 1: Land cover area in 2002, 2010, and 2018.

TABLE 1: Land cover area in 2002, 2010, and 2018.

Land Cover	Area					
	2002		2010		2018	
	Ha	%	Ha	%	Ha	%
Forest	14.069,48	12,38	13.987,3	12,31	13.979,4	12,3
Non-forest vegetation	88.446,9	77,85	85.939,2	75,61	84.260,2	74,13
Settlement area	8.758,73	7,71	11.780,4	10,37	13.584,5	11,95
Open space	2.261,6	1,99	1.897,08	1,67	1.785,65	1,57
Waters	81,22	0,07	50,498	0,04	44,71	0,03

The land cover conversion that occurred in Sukabumi Regency in the period 2002-2010 showed that on settlement land cover there was an increase of 3,007. The most significant decrease occurred in the land cover of non-forest vegetation with a decrease of 2,770 Ha. Then followed by an open land cover which decreased by 435 Ha. Last, the forest land cover has decreased by 99 ha, and waters have decreased by 34 ha (Figure 2). In the 2010-2018 period there was the most significant increase in settlement land cover of 1,805 ha and the most significant decrease occurred in non-forest vegetation land cover with a decrease of 1,715 ha, followed by open land cover which decreased by 111 ha, forest land cover decreased by 8 Ha, and waters decreased by 6 Ha (Figure 3). Then in 2002-2018 shows a decrease and increase during the period 2002-2018, from the figure shows that settlement land cover experienced the most significant increase of 4,813 Ha. Meanwhile the most substantial decrease was experienced by land cover of non-forest vegetation which amounted to 4,486 Ha, followed by open land cover namely decreased by 546 ha, forest land cover decreased by 107 Ha, and waters decreased by 39 Ha (Figure 4).

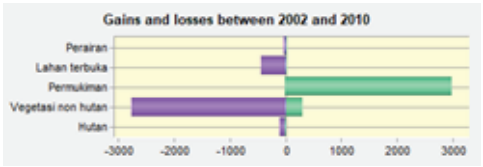

Figure 2: Gains and losses between 2002 and 2010.

Figure 3: Gains and losses between 2010 and 2018.

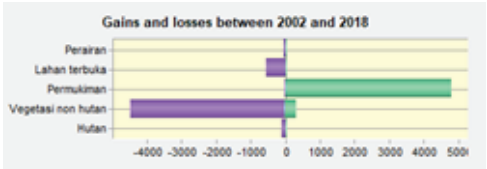

Figure 4: Gains and losses between 2002 and 2018.

In the period 2002-2010, the open land cover was land cover, which gave the most significant contribution to the increase in the area of residential land cover, which amounted to 709 Ha (Figure 5). Also, in the 2010-2018 period, the most significant contribution was given by land cover of non-forest vegetation amounting to 1,884 Ha

(Figure 6). During the 2002-2018 period,, the most significant contribution to settlements was given by covering 2,344 ha of non-forest vegetation land (Figure 7).

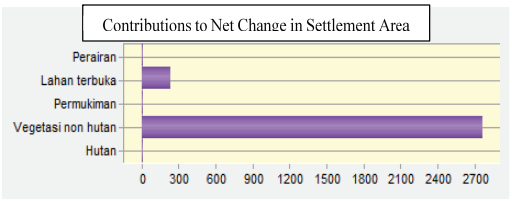

Figure 5: Contribution to the net change in Settlement area between 2002 & 2010.

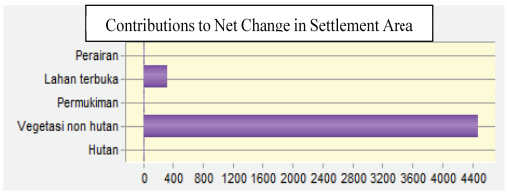

Figure 6: Contribution to the net change in Settlement area between 2010 & 2018.

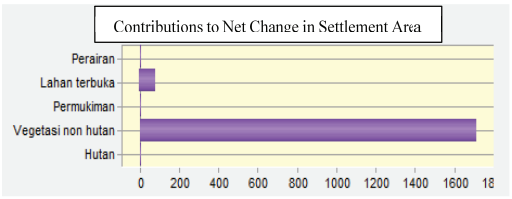

Figure 7: Contribution to the net change in Settlement area between 2002 & 2018.

Simulation is done using CA-Markov by using the driving factors that have been made before. Possibility to occur or not a change is known from the markovian value (Markov Chains Value) or Transition Probability Matrix (TPM). The amount of TPM in the 2018 simulation is shown in table 2.

TABLE 2: TPM in 2018 simulation.

	I	II	III	IV	V
I	0.8305	0.1513	0.0047	0.0000	0.0000
II	0.0000	0.8440	0.1695	0.0000	0.0000
III	0.0000	0.1501	0.8499	0.6899	0.0000
IV	0.0000	0.1433	0.1668	0.6899	0.0000
V	0.3603	0.1346	0.0000	0.0000	0.5050

Accuracy test results can be seen in Figure 8. The results obtained from the accuracy test that the kappa (Kstandard) value shows a value of 0.8732 or 87.32%. As with the first simulation before, the second simulation was conducted to get the prediction of the model in 2032 using the same driving factors, but it has different markovian values as in table 3 below.

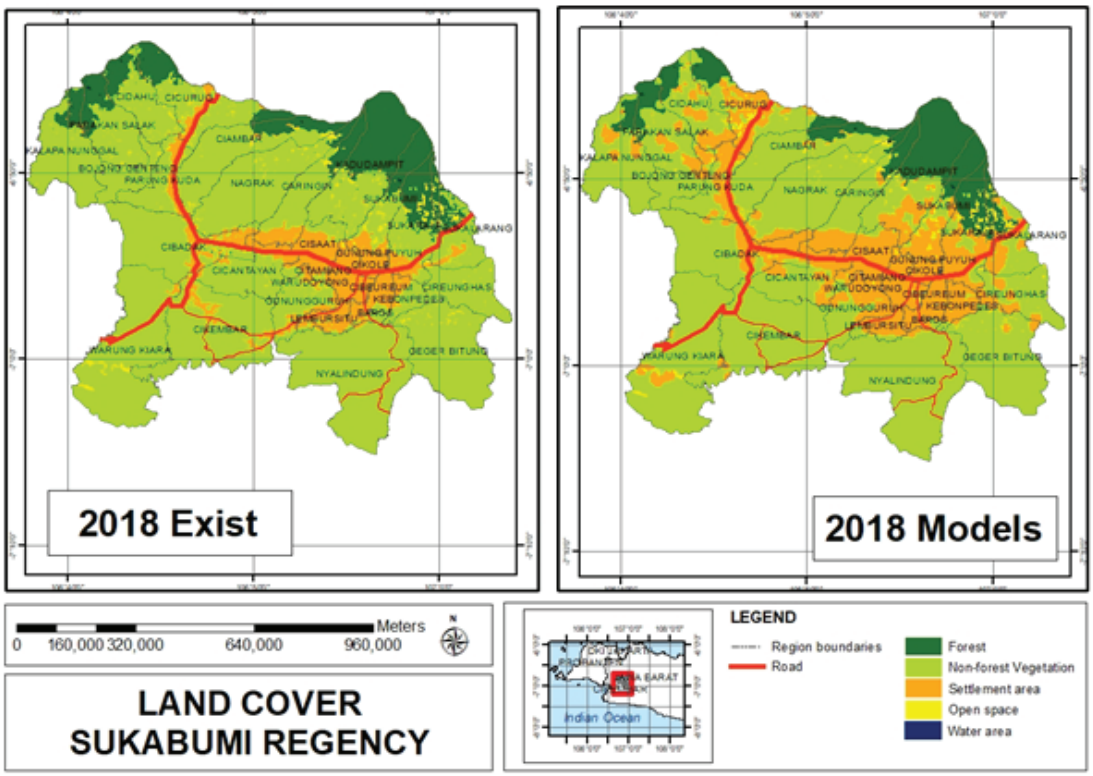

Figure 8: Existing land cover in 2018 and 2018 models.

TABLE 3: TPM in 2032 simulation.

	I	II	III	IV	V
I	0.8245	0.1210	0.0298	0.0000	0.0000
II	0.0000	0.8492	0.1715	0.0000	0.0000
III	0.0000	0.1500	0.8500	0.0000	0.0000
IV	0.0000	0.0488	0.1872	0.7640	0.0000
V	0.0000	0.2743	0.0367	0.0000	0.6891

TABLE 4: Land cover area in 2002 and 2032.

Land Cover	Area (Ha)	
	2002	2032
Fores	14.069,48	11.862
Non-forest vegetation	88.446,9	69.842,4
Settlement area	8.758,73	30.442,7
Open space	2.261,6	1426,1
Waters	81,22	34,24

Just like the 2018 model, the prediction model for 2032 is also tested for accuracy. In contrast to the 2018 model which carried out an accuracy test using data on existing land cover in 2018, the prediction model for 2032 was conducted using accuracy tests

using the RTRW of Sukabumi Regency in 2032. It can be seen that the kappa value is 0.8352 or 83.52%.

The existence of BOCIMI Tol road greatly influences changes in land cover in Sukabumi Regency, especially in the prediction model in 2032. The model results show that there is a growth in residential land cover, specifically around the BOCIMI TOL lane. This is evidenced by the use of BOCIMI TOL as a driving factor that drives changes in settlement land cover. Growth in land cover changes can be seen in Figure 11.

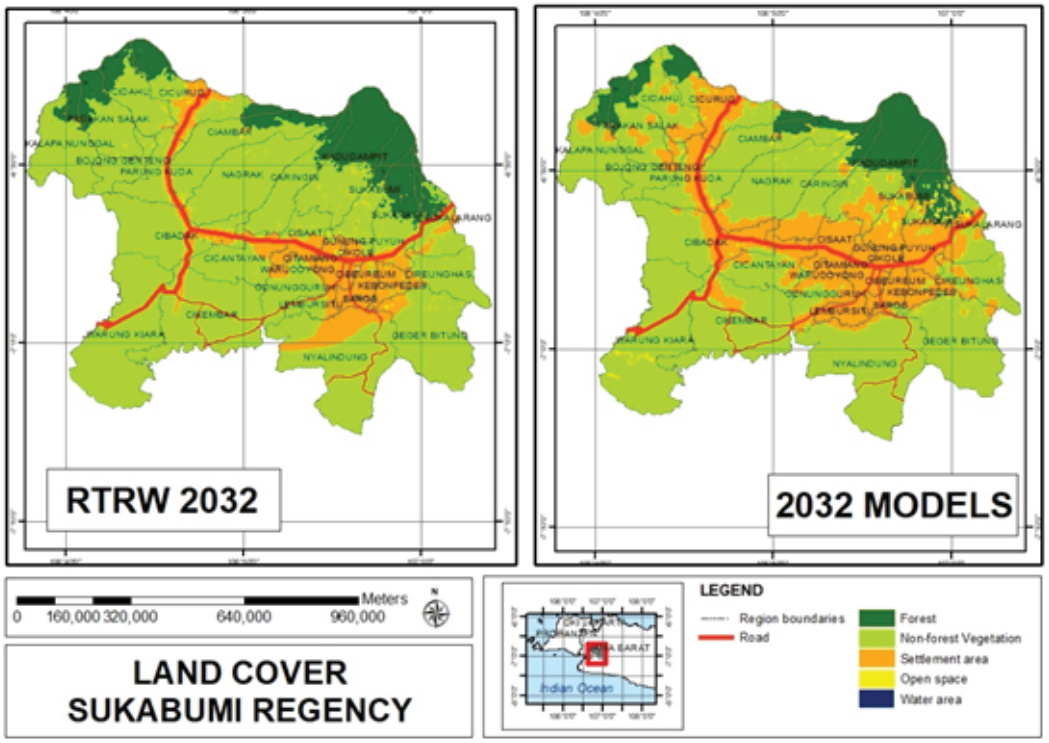

Figure 9: RTRW 2032 and 2032 model.

4. Conclusion

Changes in land cover during the period 2002-2018 or the last 16 years indicate that changes in land cover, especially residential land cover occur in areas with high driving factor values. The second model or prediction model for land cover in 2032 has good accuracy, which is 83.52%. Based on this model, residential land cover in the period 2002-2032 or the last 30 years has increased in the area. The growth of residential land cover is increasing in the central, northern, eastern, and western regions of Sukabumi Regency, which has the highest suitability according to figures from driving factors or driving factors. An increase in population also causes the development of residential land cover, so that human activity increases, which results in the emergence of new

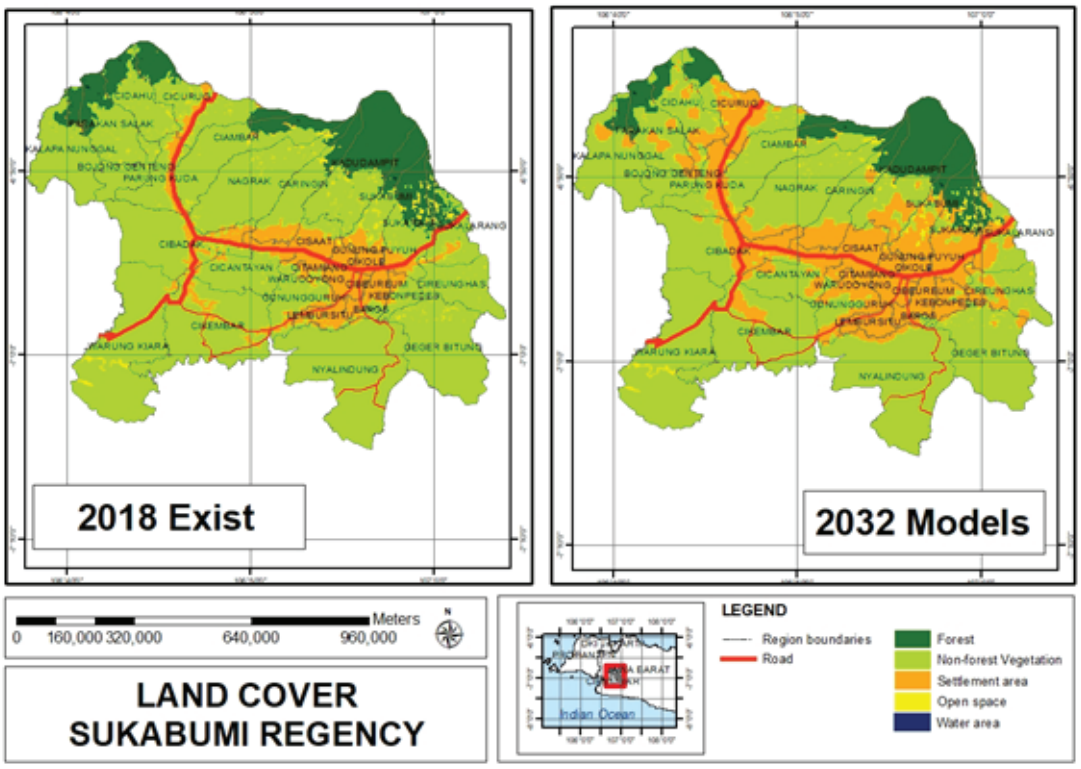

Figure 10: Existing land cover in 2018 and 2032 models.

economic points around national roads or connecting roads between regions around Sukabumi District. It also appears that there is settlement land cover in the area around the forest, this is due to the extent of non-forest vegetation land cover (one of them plantations) so that many people choose to live in the area around the plantation or where they work. One of the driving factors used is Toll BOCIMI, the growth of residential land cover has grown around the BOCIMI Toll lanes and gates so that the existence of Toll BOCIMI affects the growth of residential land cover in Sukabumi Regency.

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