Dynamic Modeling of Land Use and Coverage at Quarta Colônia, RS, Brazil

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SUMMARY

The present research intends to simulate the land use and coverage evolution tendency at Fourth Colony, RS, is the year 2018, from physical variables, analyzing the change on the land use and coverage in the period of 1988 to 2002 and 2008. The maps of 2002 and 2008 processed in the decreases EGO modeling platform enabled the global transition probabilities and gabarito, location transition probabilities were defined using weight of evidence. The physical variables demonstrated to be collaborator to process description. The simulation results were validated specially, the fuzzy method, demonstrating satisfactory results of the simulation.

SUMMARY

O presente artigo pretende simular as tendências de evolução do uso e cobertura da terra da Quarta Colônia/RS, para o ano de 2018, a partir de variáveis físicas; analisando as mudanças de uso e cobertura da terra de 1988 a 2002 e de 2002 a 2008. Os mapas de 2002 e 2008 no Dinamica EGO possibilitaram a definição das probabilidades globais de transição, e as probabilidades locais de transição pelo método de pesos de evidência. As variáveis físicas se mostraram ser colaboradoras desse processo. Os resultados da simulação foram validados espacialmente, baseado em lógica fuzzy, apresentando resultados satisfatórios da simulação.

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1. INTRODUCTION

The questions about changes in usage patterns and coverage of the earth have awakened interest, inside and outside the science, due to the accelerated process and the possible impacts environmental and socioeconomic these amendments, which cause concern local level and even global.

To a better understanding of these iterations dynamic between society and nature, i.e. between human occupation and different ecosystems, contemporary experience is essential, that points to the development and incorporation of integrated scientific models with focus on social and ecological characteristics of places and regions use.see

One of the most used simulation models in studies of landscape is the stochastic model, also called stochastic-randomized, which, through a transition matrix after changes of land use and cover and the relationship of these changes with criteria defined by evidence, weights makes it possible to define future areas that are more susceptible to new usage changes and coverage.

The study of changes in the landscape is being developed by applying modeling techniques, through the development of models. Soares Filho (1998, p. 55) reminds us that the term modeling:

> ... the process of research that leads to the generation of the model (representation) of a system. This process develops, then, by defining a set of hypotheses or predictions, which may be compared with measures of the real world. Depending on the correlation between the observed and the result generated, the template will be accepted, rejected or modified in any way, to again be tested.

Dynamic modeling seeks to overcome the limitations of technology geoprocessing, heavily based on a two-dimensional vision of static and the world, with the goal of dynamic models in GIS is perform simulation incluídonumber time-dependent processes, such as hydrological models, which simulate the flow and transport of water (BURROUGH, 1998).

For the Search proposal, simulation was used Dinâmica EGO – software acronym for Environment for Geoprocessing Objects (objects environment geoprocessing), based on cellular automata theory, being that the core of Decreases ego, responsible for the creation and implementation of models, is written in C++, while the GUI is written in Java.

Recently, the cellular automata theory concepts have been used for modeling of urban and physical phenomena (Pedrosa and Câmara, 2002). In this approach, a space is represented by a mosaic of cells, usually identical formats and sizes, and on each automaton cellphone number transition rules are applied that determine when and why State of a cell changes.

This Dinâmica EGO software uses as input parameter thematic landscape map (sourced usually remote sensing data), which is represented by a matrix. For modeling, spatial variables are considered other Cartographic (bases), which are classified in dynamic and static taking also into account other parameters that are required for the composition of the input data: annual transition rates, minimum time stay in each State, among others. As output, the software produces maps thematic landscape for each simulated time step-son (SOARES, 2001).

The Fourth Colony, which will be the area study which will develop this work, was established in 1877, being colonized mainly by German and Italian, which had view main production, not taking into account the overturned and forests modification of the geographical area of the region.

The general objective of this study was to apply a modeling system to assess the momentum for change of land use and coverage in recent years (2002-06 2008), as well as provide a simulation of a future scenario for the year 2018.

2. LOCATION OF THE STUDY AREA

The Fourth Colony, which was the study area, located in the geographic center of Rio Grande do Sul State, Brazil, between geographical coordinates 29° 09' 15.39" and 29° 58' 37,68" South latitude and 53° 55' 12" and 53° 55' 12" West longitude. It is composed of nine municipalities: Silveira Martins, Ivorá, São João do Polêsine, Faxinal Soturno, Dona Francisca, Nova Palma, Pinhal Grande, and Restinga Secaof the Rio Grande do Sul State.

3. MATERIALS

In the implementation of this research were used and cartographic materials materials processing and analysis. Cartographic materials include:

- Satellite images TM Landsat 5, orbit: 222-080 and 222-081, 04 November 1988 and March 16, 2008 in spectral bands 3, 4, 5 and satellite image of the Landsat 7 ETM+, 19 January 2002 on the same orbit-point and spectral bands to 1998 and 2008 years.
- Topography of DSG-letters prepared by the Ministry of the army – Geographical service directors (DSG) – Southern region of Brazil, all the scale 1:50.000 with printing in 1979.

Already the processing and analysis materials include computers, peripherals, computing applications such as: Georeferenced Information Processing System; IDRISI32; ER Mapper (version 7.1) and program Dinamica EGO simulation.

4. PROCEDURES METHODOLOGICAL

Satellite images of the Landsat 5 1988 year, Landsat 7 2002 year and Landsat 5 2008 year, were georeferenced in SPRING application through the capture and geographical coordinates calculation known points in analog and visible topographic cards in pictures be registered.

The digital classification of the image letter for colony maps of land use and cover was done by supervised classification, with the use of the classifier algorithm maximum likelihood that embraces the probability density function based in Bayesian statistics.

The digital classification reliability and usage earth's coverage of the Fourth Colony was evaluated from development the confusion matrix of training areas of the samples, the Kappa index formula of (SPRING application generated report after classification), considered a great statistical test confidence analysis digital classification.

For the preparation of thematic maps, all developed in the SPRING software, went to the cartographic organization (this base held previously the process of classification of the Landsat images), which was formed by territorial limit of Fourth Colony, roads and drainage network through import of digital data containing scanned during vectors forest inventory, Fourth Colony in, followed by import and georeferenced of topographic cards covering the region, in order to hold a check data of inventory forestry.

Distances–with map known in technical language as buffer's , *was grouped into classes of distances within a same range, predetermined.*

For the preparation of the report clinografico or strategy|map slopes were imported contour obtained from the Shuttle Radar Topography Mission for the SPRING application, in the format grid for a category MNT. For the classes of slopes, had your slicing, with the goal of group slope values different intervals predefined classes, indicated by De Biasi (1991), as ranges less than 5%, 5% to 12%, 12% to 30%, 30% to 47% and declividades dépassant 47%.

All thematic maps and have been re-designed rasters to a same coordinates system and: UTM *Datum Córrego Alegre zone 22 South.* The spatial resolution of all data is re-sampled to 30 metres, as well as the scale 1: 60000; also all maps were left with the same number of rows and columns (3646) (3007).

The maps in TIFF/GeoTIFF IDRISI were imported into the application, initially observed minimum and maximum values for x and y coordinates, and the number of rows and columns must be equal to usage and maps coverage of the earth and a color palette conversion of legend maps through the application of the "Edit".

The initial use maps and end, in addition to these initial procedures Idrisi 32 were interpolated in the transitions occurring a class to another through GIS Analysis operation – Statistics – CROSSTAB.

The next procedure was to build a cube data in the application ER Mapper (Earth Resource Mapping), which contains the native file format recognized for reading in data processing, dynamic program will be used for the simulation model.

In Dinâmica EGO software, the procedures below in sequence related:

– Calculation of the unit and transition matrices from periodic reports use and initial coverage of the earth (2002) and end (2008);

– Striping, i.e., determining the distance bands or slices (ranges) for each transition;

– Calculation of evidence as weights of the variables that have check influence for the template, otherwise should be withdrawn;

– Applying correlation calculation of maps: cetan Cramer (V) and the uncertainty of Joint load(u) information, also to check the forvariable influences for the template;

– For 2008 model simulation, using as initial use map and coverage 2002 and applying the model validation through fuzzy method using the procedures of exponential decay function and the function decay constant;

– The model was a simulation for the year 2018 using as initial map real use map of 2008.

5. RESULTS

In relation to the Kappa index, classification analysis was found for the years 1988, 2002 and 2008 values around 0.99 – which is the scale proposed by LANDIS et al.(apud ESTEVAM, 2006), in the range of 0.80 – 1,0, band considered by the authors as being of excellent quality for a classification supervised. The observation of the usage reports and coverage of the Earth, made from satellite images relating to periods of 1988, 2002 and 2008 can be viewed in the last two used in modeling process (Figure 1), the observation that the major changes of use occurred in the field of reduction in the period 1988 to 2002, focused on a large part to the use of livestock, confirm trends today to increase mainly the production of agricultural products Government incentives, allies have an integrated process modernization fomented by the expansion of capitalism in agrarian space Brazilian. Other usages had changes, but in smaller proportions, as can be observed through Table 1 preview, which shows the evolutionary process between the classes of land use and cover.

Table 1: Usage areas and coverage land Fourth Colony/RS in hectares.

Use Classes and coverage Earth	*Use 1988*	*Use 2002*	*Use 2008*
Forest	89,187	92,941	93,217
Field	117,726	103,807	101,332
Agricultural soil	85,155	91,504	96,544
Water	2,050	5,866	3,025
Total	294,118	294,118	294,118

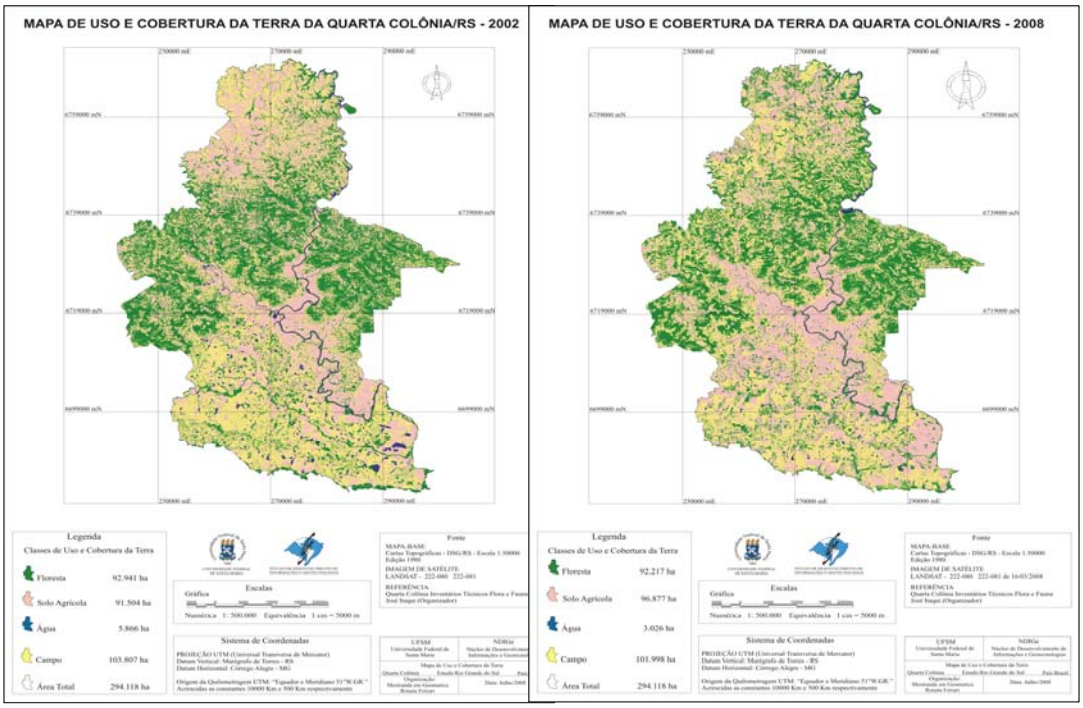

Figure 02. Use maps and land coverage Fourth Colony/RS-Brazil 2002 and 2008 years.

Reviewing the results of modeling process in decreases, initially transition matrix, resulting from the cross tabulation operation between initial coverage maps (2002) and the end (2008), which provides the percentage usage and conversion of land coverage that is, in the particular case of this research, the overall probability Markov matrix (transition), Table 2.

Table 2. Use transition matrix and fourth land coverage Colonia between 2002 and 2008.

Use and Land Cover		2008		
		Field	Forest	Agricultural soil
2002	Field	1	0,2258	0,1174
	Forest	0,1624	1	0,3543
	Agricultural soil	down	0,3296	1

In relation to the estimates of likely locations transition that consists in establishing a set of variables independent, that Dinâmica EGO, were certain bands distances (ranges) for each use and transition, whose coverage considered variables used to explain each transition were buffer map drainage, clinográfico and map each use distances and coverage land, denotation is presented in Table 3.

Table 3. Independent variables using transitions and coverage land: 2002-2008

Notation	***Variables change of land use and cover***
distance/distance_to_2	distance Field
distance/distance_to_3	distance Forest
distance/distance_to_4	distance Bodies of water
distance/distance_to_5	distance Agricultural soil
static_var/buffer	buffer Drainage
static_var/clino	Clinográfico

With the determination of distances–with held the calculation of probabilities transition locations, i.e. use transition probabilities and coverage of the Earth in each cell, performed based on the values of positive evidence weights (W +). And also the decreases EGO check whether dependency between variables, maps using the index Cramer (V) and the Joint Information Uncertainty (U) or "index of joint information uncertainty" (BONHAM-CARTER, 1994).

Bonham-Carter (1994) embraces the threshold of 0.5 to decide on the inclusion (V or u < 0,5) or exclusion (V or u > 0,5) variables in the model. With the data generated that were exposed in Table 4, Cramer any value greater than 0.5, confirming, Therefore, that the variables previously selected could be employed both in the template, but in the "index of joint information uncertainty" the distance 5 (farmland) analysis to two pairs of variables -

greater than 0.5, was dropped from participation in the explanatory variables in weights of evidence.

Table 4. Presentation exploratory analysis data by index variable and Cramer "Index of joint information uncertainty".

First variables	*Monday variables*	*Cramer*	*"Uncertainty joint information "*
distance/distance_to_3	distance/distance_to_4	0,349144	0,449424
distance/distance_to_3	distance/distance_to_5	0,492449	0,645437
distance/distance_to_3	static_var/buffer	0,221705	0,0431558
distance/distance_to_3	static_var/clino	0,450908	0,520734
distance/distance_to_4	distance/distance_to_5	0,321206	0,434352
distance/distance_to_4	static_var/buffer	0,189759	0,0299027
distance/distance_to_4	static_var/clino	0,408086	0,40127
distance/distance_to_5	static_var/buffer	0,222911	0,0420582
distance/distance_to_5	static_var/clino	0,443399	0,548555
static_var/buffer	static_var/buffer	0,224285	0,0458912

The model simulation step for 2008 year, and subsequently to 2018, was necessary to use the two transition algorithms Dinâmica EGO, responsible use change allocation and coverage of the earth: the and the *Expander.header , patcher whose determination sizes spots was determined on the basis of a visual Analysis 4.2.2.drive attempts of the model sizes spots different makes an ideal medium size value of 50 ha, spots and variance in each algorithm and 1.5 isometry.*

In relation to the model validation, can be observed, taking into account the fuzzy method using exponential decay *"function"*, the generated model for 2008, subsequently designed to 2018, presented a similarity average around 52% between the actual map 2008 and its simulation, whereas changes between 2002 and 2008. The map above in Figure 2 shows spatially the errors that include both the omissions (areas where there was change from 2002 to 2008 and do not appear in the simulation) commissions (areas where there has been no change in fact, but appear as change in the simulation) and simulation hits.

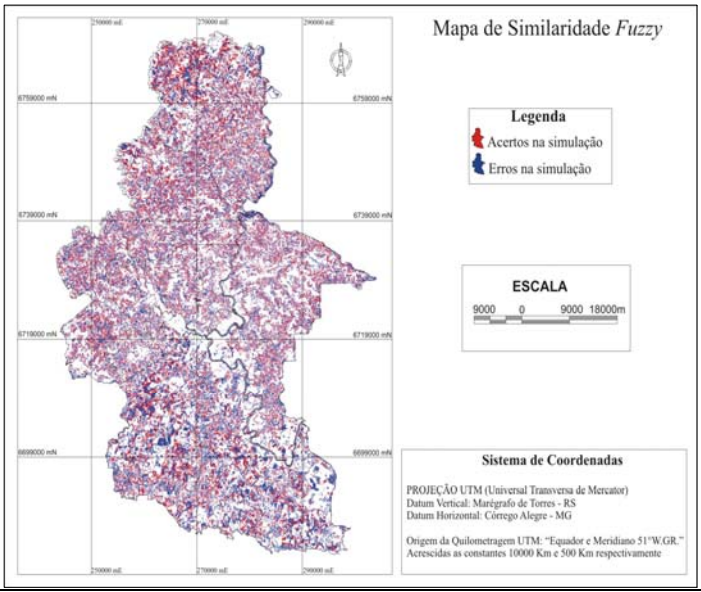

Figure 2. Similarity map view, based on fuzzy *"exponential decay function "*.

The Table 5 presents the similarity indexes fuzzy, *whereas "constant decay function for the simulation produced by model for 2008, being the result of such analysis may be adjustment satisfactory with effectiveness, because decreases EGO be a program that performs rigorously analysis.*

Table 5. The validation result for different window sizes

Model	***Window size (Pixels)***	***Parameters of the spots (HA)***	***Similarity index Fuzzy (ISF)***
Simulation 2002-2008	3	50	0,448406
	5		0,592447
	7x7		0,704441
	prototypical		0,785147
	11x11		0,842805

The ISF (similarity indexes is considered Fuzzy) an evaluation method flexible concordance is not based on tuning pixel to pixel, but in many resolutions, in which the values This tend to be higher when compared to indices of agreement rigid, this increased the sampling window size; This way, at the above resolution 11 or 13 pixels, occurs typically a saturation, showing that very large Windows ISF becomes inefficient in assessing adjustment between the real and simulated map.

The simulation model generated for 2018, physical variables based presented as a result the potential usage transitions and coverage of the Earth the 2008 annual period until 2018, which has been quantified in SPRING with larger details and can be viewed in Figure 3, whose evolutionary of quantification land use and cover the fourth colony 2008-2018 appear in Table 6, in which it noted that, in terms of total area without specification for use and coverage in 2018 tend to not have major changes compared the year 2008, as is a geographical region, in large part start, with mountains, agricultural expansion in these areas, as well as the deforestation, are limited.

To carry out an analysis with larger specificity, the quantification of each change forecasts use class and coverage of earth 2008-2018, noting that for the class field, there was a greater tendency to stay in 36,14% with consequent greater change forecast for farmland, with 32,40% role of development policy, above all, Agriculture, and a more intensive animal husbandry. The field areas that tend to a forest regeneration around 31,16% are, in their a large majority, located on the edge of forest areas that were already over and the drains. This last finding is the reconstruction of forest-bordering, whose supervision in the region is intensifying purposes– time and tends to remain with greater emphasis.

The forest class tends to stay in greater quantifying spatial 42,70%, mainly in mountainous areas. But tends to significant changes occur in 32,66% and 24,37% in areas for field and farmland, demonstrating a propensity to deforestation continuity in areas conducive to the development of agriculture and livestock.

The agricultural soil following tends to changes in 36,83% field the area, used mainly for livestock, and changes smaller forest in 21.66% of agricultural soil areas, with the trend of abandonment of sloping areas, areas that do not allow mechanization and planting in some areas of eucalyptus, used for marketing, unchanged 41,04% of agricultural land area.

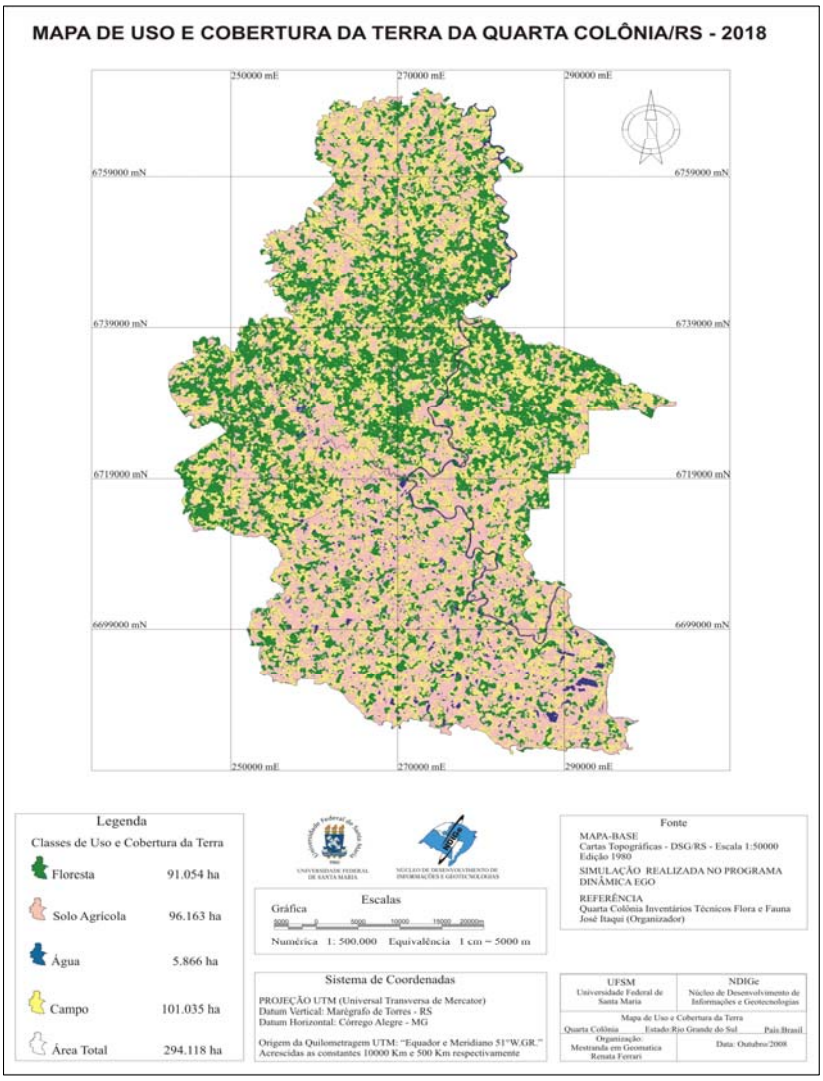

Figure 3 Use simulation map and coverage of the Earth the Fourth Colony/RS-2018.

Table 6: Use evolutionary areas and coverage of the Earth the fourth Cologne/RS in ha.

Use Classes and coverage Earth (hahalom.)	*Use 1988*	*Use 2002*	*Use 2008*	*Forecast Use 2018*
Forest	89,187	92,941	92,216	91,054
Field	117,726	103,807	101,332	101,035
Agricultural soil	85,155	91,504	96,544	96,163
Water	2,050	5,866	3,025	5,866
Total	294,118	294,118	294,118	294,118

6. CONSIDERATIONS FINAL

To generate a stochastic model that implements the evolution of land use and cover the Fourth Colony for the year 2018, the central goal of this work, measured these, principal annual simulations result, 2008-2018, finding areas where tend to occur losses or adding of usages and coverage of the Earth. This location demonstrated the process of land occupation that this region is suffering over the 20 years examined, although the model be used for understanding only the last 6 years.

The quantification of simulated 2018 map also contributes to reaffirm that the trends of development (increase/decrease) remain virtually the same views changes land use and cover between periods of 1988-2002 and 2002-2008, despite the agricultural and forest soil classes have not followed the trend of increasing and Yes have a small reduced 0.381hectares and 1.162 hectares respectively, in the simulation 2018. This tendency of classes in 2018, the class that can lead to present greater permanence without amendment is the forest, in 42,70% of its area, and the biggest transitions tend to be field to agricultural soil of 36,83 % in the year 2018 is the field area, which tends to be of 101,035 ha.

The platform used for modeling in Dinâmica EGO proved satisfactory compliance of the objectives of this work, by support, and other characteristics, an open and flexible framework for the use of different methods of parameterization and variable sets which associated wisely, attended the specificities of modeling study area, with special patterns of coverage conversion use and land cover.

The use of spatial statistical method evidence weights, which decreases EGO is implemented in, demonstrating the local transitions probabilities of cell to parameterize the process simulation of likely changes of land use and cover the Fourth Colony was instrumental in obtaining, partially, the variables really would be constituent part of the model.

In addition, be overemphasized that, despite all the evidence point to the assertion that models have had over time advances represented by the advent of models based in cellular automata theory and by your facilities of link the GIS data, you must mention that there are limitations and disabilities implicit in current traditional implementations of these models. They are linked mainly to the discretization of space and time, but many efforts to resolve the problems of space over stationarity time are being provided, leading to dynamic models cellular automata theory-based space as a promising means of dissemination simulation outputs to local and regional managers, as well as public can take attitudes to improve the environment in which they live.

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BIOGRAPHICAL NOTES

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