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Forecasting Habitat Conversion of Eastern Corridor of Selous-Niassa Transfrontier Conservation Areas (TFCA)

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Abstract

This paper explore the less known spatial and temporal changes that expected to occur for a period of 20 years from 2015 to 2035 in land use and land cover and their impacts on terrestrial ecosystem services of Selous-Niassa TFCA. Objectives of the study were to forecast the spatial and temporal changes of land use/cover, amount of trees that will be lost, and expected wood balance. The study employs field survey, remote sensing and GIS techniques to assess spatio-temporal dynamic of land use/cover. The study has revealed that there will be significant land use and vegetation cover transformation from one class to another till the year 2035. The bushland and grassland will dominate by occupying 56.29% of the corridor followed by cultivated land which is expected to cover 22.75%. Natural forest (closed and open woodlands) coverage will decrease from 310 140 ha (21.21%) existing in 2015 to 293 671 ha (20.08%) in 2035, built up area will increase from 8851 ha (0.61%) existing in 2015 to 12 749 ha (0.87%); and water surface will decrease from 646 ha (0.04) in 2015 to 242 ha (0.02) in 2035. Also, the results revealed gain of trees regenerated in the study area during the period 1986 - 1997 with an average of 3.5 million trees per year. Besides, there was rampant conversion of woodland in the study area during the period 1997 - 2016 with average loss of 27 million trees per year. Wood supply in the study area for the year 2016 is at least 25 times the average demand per year per capita. Conversely, the trend of wood supply from 1986 to 2016 shows dramatic deforestation of the area which implies tragedy of commons and is the public property where there are no control policies or rules. The study recommends an emergence of reviewing management and conservation strategies is unexceptional if we need sustainability of Selous-Niassa TFCA.

Keywords: Land Use and Land Cover Change (LULCC), Ecosystem Services, Tree loss, Wood Balance

Introduction

Background information

Continuous wildlife habitat loss is an inhibited phenomenon over several decades. Habitat loss is extremely large in African countries where much of connected ecosystem between two or more protected areas (PAs) of different categories are unfenced [1-5]. The area that used to connect these protected areas can be buffer zone or wildlife corridor/dispersals/routes or others. Mostly these areas that connect two or more PAs consists of living dwellers who can utilize existing resources without considering sustainable supply of ecosystem services to both human, biodiversity and wildlife that use the areas for migration and adapting to hazards like fires, climate change and dangerous species to their survival [6,7]. Understanding these areas and including in core PAs by any means is unexceptional for sustainable conservation of connected ecosystem or transfrontier conservation areas (TFCAs). TFCAs network can be a trusted conservation strategy for PAs connecting two or more countries within the continent or trans-continent [8-10]. Selous-Niassa TFCA is unexempted from this scenario. The TFCA is connected with the corridor known as Selous-Niassa Wildlife Corridor (SNWC) which extends from borders of Southern Selous Game Reserve in Tanzania to Northern Niassa Game Reserve in Mozambique at Ruvuma River which is the international border between the said countries.

Wildlife corridors formulated with the core functions of responding to ecological and socioeconomic benefits of connected ecosystems of PAs. Within corridors with much extended areas between two or more core PAs insist the local community to conserve habitat, biodiversity, wildlife and other resources so as attaining sustainability. Under so doing, land use planning and introduction of CBNRM (Community Based Natural Resources Management) in these corridors is of utmost implementation [2-5,10]. Besides, sustainability of these CBNRM must obey the rules that "conservation benefit should offset cost" to rural communities. Land use planning must consider foreseeable future circumstances which must involve forecasting and evaluating future land use by using techniques that minimize uncertainties.

Problem statement

Forecasting and evaluating future land change is a complex set of tasks and, hence, it has to be performed after a deep scientific knowledge of the extent individuals, characters, as well as consequences of land transformation have been gathered [5,10,11]. A typical land use planning process requires the landscape planners to realise, classify, and investigate the current circumstances in order to project future probable development patterns, and propose plans based on available information [5]. According to planners usually approach this task in two ways, a predominant or traditional approach and an analytical approach. The traditional approach foresees a future land use outcome and then prioritises present-day policies required to achieve that outcome. The analytical approach simulates alternate current strategies and compares their consequences. A recent pervasive approach to consider and simulate human decisions in LULCC is the use of multi-agent systems (MAS) [12-19].

MAS are defined as modeling tools that allow entities to make decisions according to the predefined agents, and the environment also has a spatial explicit pattern. In fact, agents in the system might represent groups of people or individuals, etc. [20-22,16]. The study focused on drawing attention to future land use and land cover of Selous-Niassa TFCA with much focus to SNWC which connect the two PAs and consist of corridor dwellers who depend their livelihoods from the corridor. Thereof, forecasting land use of the area, amount of trees loss, and wood balance is of an urgency so as to have proper utilization and conservation strategies.

Materials and Methods

Materials

Description of the Study Area

The study was carried out in eastern Selous-Niassa TFCA with an area of 1, 462, 560 hectares called eastern Selous-Niassa wildlife corridor (SNWC) or Selous-Masasi which extends across southern Tanzania into northern Mozambique between 10^0S to 11^0 40'S with north-south length of 160 to 180 km. Administratively the study area comprises three districts namely Liwale, Nachingwea, and Nanyumbu (Figure 1).

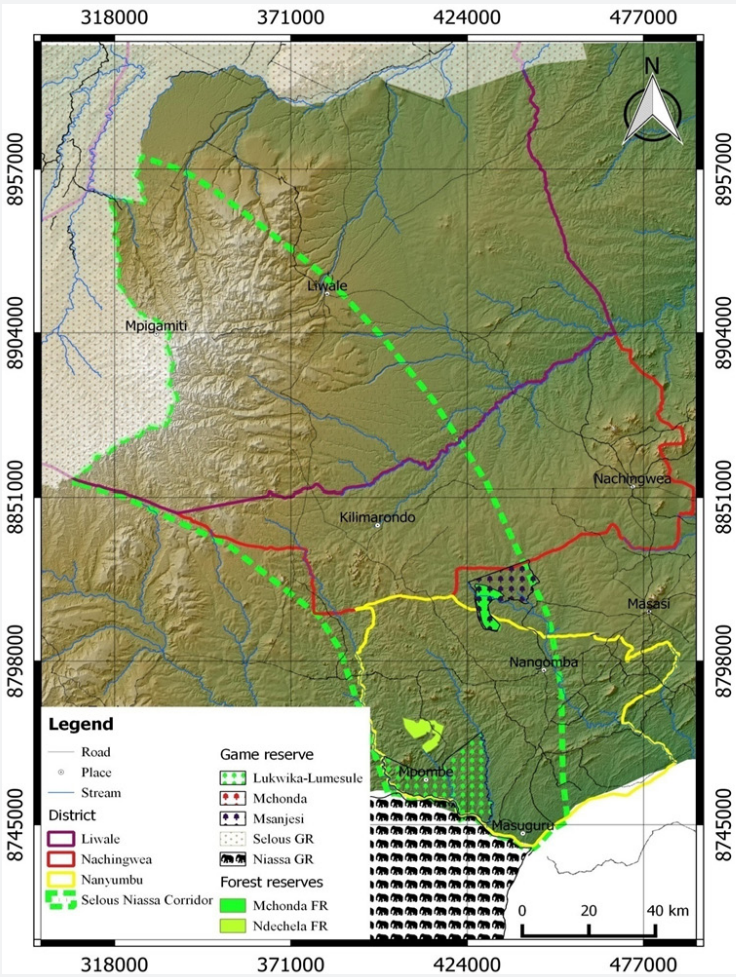

Figure 1: The Map of the study area.

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Methods

Spatial data includes satellite images and digital elevation model (DEM) downloaded from

USGS - GLOVIS.

Data analysis

To predict the future changes in land use/cover in eastern Selous - Niassa TFCA

The present study utilized Markov Chain Analysis and Cellular Automata Analysis, jointly called CA-Markov, to predict and simulate the future change of land use and land cover in the Selous-Niassa TFCA by the year 2035.

CA - Markov Chain Analysis

Markov chain is a statistical tool that describes the probability of land use to change from one time period to another by developing a transitional probability matrix between first period and second period based on the neighborhood effects [23-25]. This model was based on using and evaluating land use layers of previous years to predicting the spatial distribution of land uses in the future [26]. For the better simulation for temporal and spatial patterns of land use changes in quantity and space, the combination of Cellular automata and Markov chain (CA-Markov) were developed. The simulated model was developed by using IDRISI Selva 17.0 software and it involved two main stages which are calculating conversion probability (conversion probability matrix, conversion area matrix and layers of conditional probability) done by using Markov chain analysis, and the second stage was spatial specification of land use coverage simulated based on CA spatial operator and multi criteria evaluation (MCE). In the developing CA Markov model, the classified land use map of 1990 which represent past, and 2015 which represent present time were converted into IDRISI data format) (Figures 2 & 3) and selected to be input data into the model, to calculate matrices of conversion probabilities and conversion areas (Transition area matrix and transition probability matrix). The transition probability matrix (Table 1) expresses the likelihood that a pixel of a given class that will change to any other class (or stay the same) in the next time period. This could be derived from transition areas matrix by knowing the total cells of each class. The transition areas matrix (Table 2) expresses the total area (in cells) expected to change from the year 2015 to the year of 2035 according to those changes happened from 1990 to 2015. In the final step of predicting and simulation the future change of land use and land cover, the land use map of 2015 was used as a base map, together with conditional probabilities data and matrix conversion probabilities were integrated using the CA spatial operator based on Markov chain analysis and MCE.

Table 1: Transitional probability matrix for land use/cover to change between 1990/2015.

Given	Probability of a cell to change (transition) to						
	CWD	OWD	BS	GL	WTR	BLT	CL
CWD	0.1716	0.2419	0.2578	0.176	0.0001	0.0027	0.15
OWD	0.0559	0.1564	0.2821	0.2483	0.0001	0.0062	0.251
BS	0.031	0.1497	0.3597	0.3105	0.0001	0.0042	0.1448
GL	0.0199	0.0975	0.3813	0.2879	0.0006	0.0092	0.2035
WTR	0	0	0	0.6609	0.3391	0	0
BLT	0.0487	0.0779	0.2366	0.4436	0.0006	0.0376	0.1549
CL	0.0265	0.0891	0.3432	0.3521	0	0.0202	0.1688

CWD = Closed woodland, OWD = Open woodland, BS = Bushland, GL = Grassland, WTR = Water, BLT = Built Up area, and CL = Cultivated land.

Table 2: Transitional area matrix for land use/cover change between 1990/2015.

Given	Area in cells expected to change						
	CWD	OWD	BS	GL	WTR	BLT	CL
CWD	171422	241691	257582	175840	59	2659	149838
OWD	136846	382630	690221	607619	141	15062	614201
BS	165394	799051	1919142	1656696	635	22290	772811
GL	87004	427493	1671288	1261817	2750	40443	891863
WTR	0	0	0	4742	2433	0	0
BLT	4794	7658	23269	43624	58	3698	15235
CL	78901	265483	1022734	1049308	79	60339	502909

CWD = Closed woodland, OWD = Open woodland, BS = Bushland, GL = Grassland, WTR = Water, BLT = Built Up area, and CL = Cultivated land.

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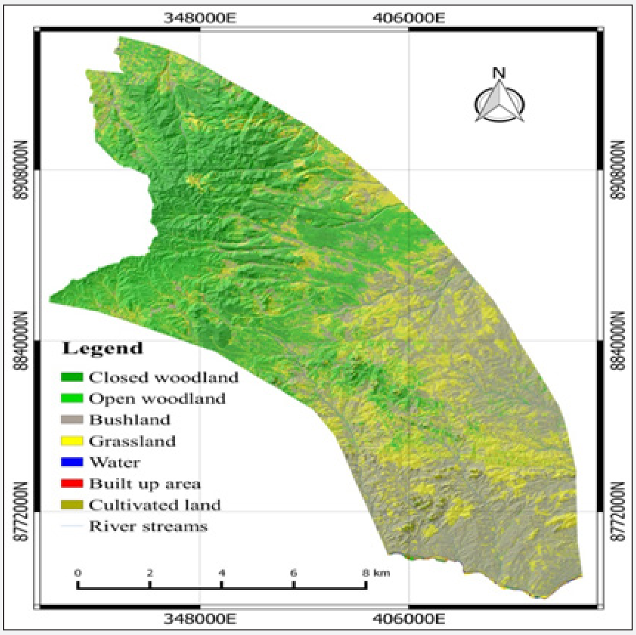

Figure 2: Land use/cover 1990 used in developing CA Markov model.

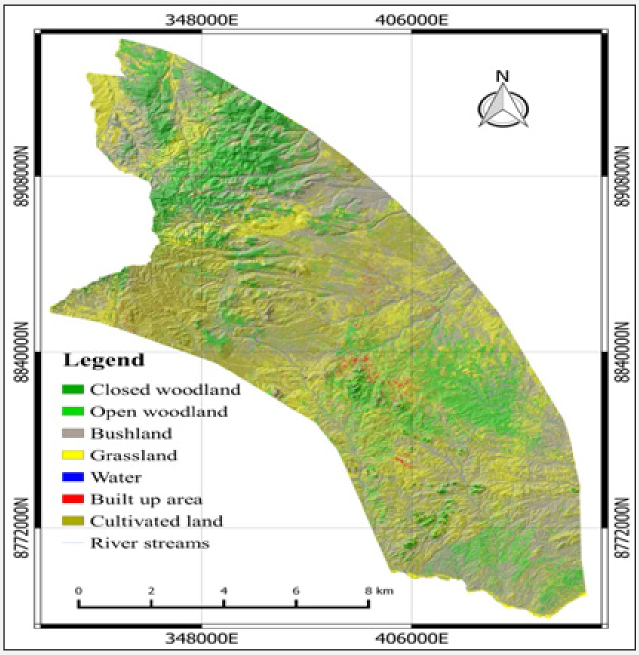

Figure 3: Land use/cover 2015 used in developing CA Markov model.

CA - Markov model validation

For model validation the simulated land use/cover map for 2015 was compared with the actual satellite derived land use/ cover map based on the Kappa statistics. Then, standard Kappa index is used to check whether the model is valid or not (usually the Kappa Index for a valid model is >70%). If the model has the Kappa Index less than 70% then the suitability map for the land covers and filter used should be repeated based on several considerations. Using VALADATE tool, IDRISI gave the standard Kappa of 0.83, Kappa for no information of 0.89, Kappa for grid-cell level location of 0.86 and Kappa for stratum-level location of 0.864 which are all more than 0.7.

To estimate amount of trees loss of eastern Selous-Niassa TFCA from 2015 to 2035

Amount of land (in hectares) in the study area that expected to be converted from closed and open woodlands to other socio-economic activities is used to estimate number of trees loss. The study area belongs to southern zone as classified by URT. The number of trees and volume per hectare of the distribution of forest and woody vegetation resources have been classified by employing methodology used by NAFORMA (URT, 2015) of measuring all trees with Dbh of one cm and above as shown in (Table 3).

Table 3: Distribution of forests and woody vegetation resources of the study area.

Districts	Average mean volume m^3/ha	Average number of trees/ha
Liwale, Nachingwea & Nanyumbu	49.3	1,654

To analyse wood balance of corridor dwellers of eastern Selous-Niassa TFCA in 2035

Projected human population of corridor dwellers in 2035 is estimated based on National Bureau of Statistics (2012) census and computing average demand for wood compared with supply from the corridor ecosystem. The study employed NAFORMA baseline information that estimates Tanzania's average demand for wood as 1.39 m^3/year/capita while the annual allowable cut (the sustainable supply) is estimated at 0.95 m^3/year/capita.

Results and Discussion

Future change in land use and land cover in eastern Selous-Niassa TFCA

Table 4: Land use/cover area distribution in 2035.

LULC	2015		2035	
	(Ha)	(%)	(Ha)	(%)
Closed woodland	89923	6.15	81981	5.61
Open woodland	220217	15.06	211690	14.47
Bushland	480269	32.84	411950	28.17
Grassland	394461	26.97	411272	28.12
Water	646	0.04	242	0.02
Built up area	8851	0.61	12749	0.87
Cultivated land	268193	18.34	332676	22.75
TOTAL	1462560	100	1462560	100

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The land use land cover map for the next 20 years is presented in (Figure 4) below.

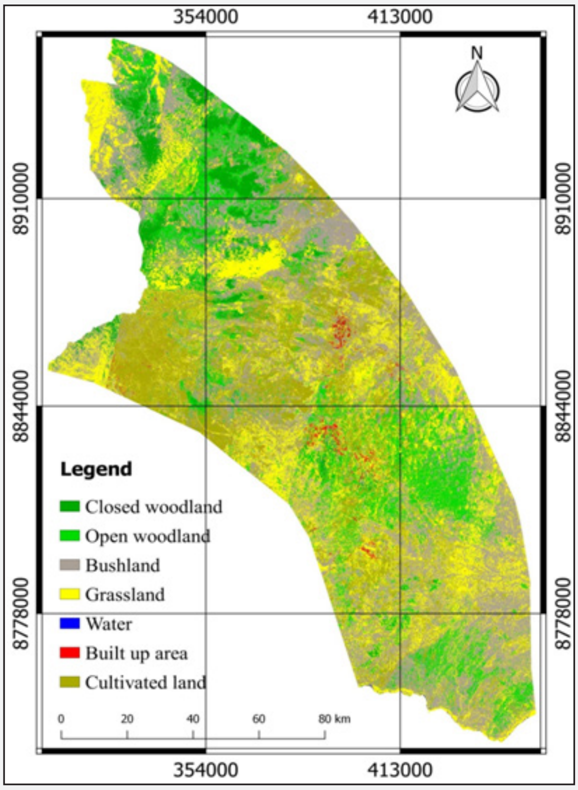

Figure 4: Projected Land use/cover map for eastern Selous-Niassa TFCA for 2035.

The statistical analysis of land use land cover for the predicted year 2035 illustrated in (Table 4). An overall change in land use and land cover in all the twenty years of prediction revealed that, the bushland and grassland will dominate by occupying 56.29% which is equivalent to 823 222 ha of the corridor followed by cultivated land which is expected to cover 22.75% equivalent to 332 676 ha. Natural forest (closed and open woodlands) coverage will decrease from 310 140 ha (21.21%) existing in 2015 to 293 671 ha (20.08%) in 2035, built up area will increase from 8851 ha (0.61%) existing in 2015 to 12 749 ha (0.87%); and water surface will decrease from 646 ha (0.04) in 2015 to 242 ha (0.02) in 2035. As explained by Lobora et al. (2017) that, decrease in natural forest cover impact water resource, this has been revealed in this study due to projected decrease in water bodies and wetland.

Amount of trees loss in eastern Selous-Niassa TFCA from 2015 to 2035

Table 5: Forecasted amount of trees loss from 2015 to 2035.

Year	Total area converted (ha)	Total volume Million m^3	Number of trees loss/gain (in millions)
2015 - 2035	+ 16469	+ 0.8	+ 28

Table 5 shows expected amount of trees to be loss in eastern Selous-Niassa TFCA for 20 years from 2015 to 2035 as 28 million trees. The results revealed average trees loss of 1.4 million trees per year. This implies that, the loss will be due to conversion of the area to other socio-economic activities which are environmental destructive but economic rewarding.

Wood balance of corridor dwellers of eastern Selous-Niassa TFCA

Forecasted existing amount of trees in 2035 (Table 6) used to estimate wood balance by using estimated population of the study area in 2035. The results reveled in Table 6 shows that, wood supply in the study area for the year 2035 will be 20 times the average demand per year per capita. This implies that the area will still be partially degraded if and only if no immigrants will invade the area and encroaching existing resources. The emergence of reviewing management and conservation strategies is of urgency for the time being so as to plan for sustenance of Selous-Niassa TFCA.

Table 6: Forecasted existing amount of trees in 2035.

Year	Total woodland area (ha)	Total volume Million m^3	Number of trees (in millions)	Estimated human population	Wood balance (trees/capita/year)	Wood balance (m^3/year/capita)
2035	293, 671	14.5	486	535, 446	908	27.1

References

1. Munishi PKT, Mringi S, Shirima DD, Linda SK (2010) The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Journal of Ecology and the Natural Environment 2(12): 261-269.
2. Ryan CM, Williams M, Grace J (2011) Above- and belowground carbon stocks in a miombo woodland landscape of Mozambique. Biotropica 43(4): 423-432.
3. Holmern T, Mkama S, Muya J, Røskaft E (2005) Intraspecific prey choice of bushmeat hunters outside the Serengeti National Park. Tanzania: A Preliminary Analysis. African Zoology 41(1): 81-87.
4. WWF (2014) Tanzania's wildlife management areas: A 2012 status report. Dar es Salaam: WWF.
5. Lobora A, Nahonyo C, Munishi L, Caro T, Foley C, et al. (2017) Modelling habitat conversion in miombo woodlands: insights from Tanzania. Journal of Land Use Science. 12(5): 391-403.
6. Jewitt D, Goodman PS, Erasmus BF, OConnor TG, Witkowski ET (2015) Systematic land-cover change in KwaZulu-Natal, South Africa: Implications for biodiversity. South African Journal of Science 111(9-10): 1-9.
7. Jenkins CN, Joppa L (2009) Expansion of the global terrestrial protected area system. Biol Conserv 142(10): 2166-2174.
8. Core Team R (2016) R: A language and environment for statistical computing R Foundation for Statistical Computing. Vienna.
9. Chase MJ, Schlossberg S, Griffin CR, Bouché PJ, Djene SW, et al. (2016) Continent-wide survey reveals massive decline in African savannah elephants. PeerJ 4: e2354.

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10. Caro T, Davenport TR (2016) Wildlife and wildlife management in Tanzania. Conserv Biol 30(4): 716-723.

11. Bailey KM, McCleery RA, Binford MW, Zweig C (2016) Land-cover change within and around protected areas in a biodiversity hotspot. Journal of Land Use Science 11(2): 154-176.

12. National Bureau of Statistics (2012) The 2012 population and housing census. Tanzania National Website.

13. Parker CP, Baltes BB, Young SA, Huff JW, Altmann RA, et al. (2003) Relationships between psychological climate perceptions and work outcomes: a meta-analytic review. J Organiz Behav 24(4): 389-416.

14. Hilty JA, Lidicker WZ, Merenlender AM (2006) Corridor Ecology, the science and practice of linking landscapes for biodiversity conservation.

15. Robinson AB, Robinson NE, Soon W (2007) Environmental Effects of Increased Atmospheric Carbon Dioxide. Journal of American Physicians and Surgeons 12: 79-90.

16. Valbuena D, Verburg PH, Bregt AK (2008) A method to define a typology for agent-based analysis in regional land-use research. Agric Ecosyst Environ 128(1-2): 27-36.

17. United Republic of Tanzania (URT) (2015) National Forest Resources Monitoring and Assessment of Tanzania Mainland. Ministry of Natural Resources and Tourism, Dar es Salaam.

18. Barber CP, Cochrane MA, Souza CM (2014) Roads, deforestation, and the mitigating effect of protected areas in the Amazon. Biological Conservation 177: 203-209.

19. Bright EA, Rose AN (2014) The landscan global population distribution project: Current state of the art and prospective innovation. Oak Ridge National Laboratory (ORNL).

20. Bonabeau E (2002) Agent-based modeling: Methods and techniques for simulating human systems. 99: 7280-7287.

21. Sawyer S (2003) Conceptual Errors and Social Externalism. The Philosophical Quarterly 53(211): 265-273.

22. Crawford JR, Bedford A, Henry JD (2005) Personal disturbance scale: Factor structure confirmed in a large nonclinical sample. Psychol Rep 96(1): 107-108.

23. Araya YH, Cabral P (2010) Analysis and Modeling of Urban Land Cover Change in Setúbal and Sesimbra, Portugal. Remote Sensing 2(6): 1549-1563.

24. Al-Bakri JT, Duqqah M, Brewer T (2013) Application of Remote Sensing and GIS for Modeling and Assessment of Land Use/Cover Change in Amman/Jordan. Journal of Geographic Information System 5(5): 509-519.

25. Wang M, Zhou Z, Jingmai K, Zelenkov N (2014) A new diverse enantiornithine family (Bohaiornithidae fam. nov.) from the Lower Cretaceous of China with information from two new species. Vertebrata Palasiatica 52: 31-76.

26. Wu N, Silva E (2010) Artificial/intelligence solutions for urban land dynamics: a review. J plan Lit 24(3): 246-265.

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