BIODIVERSITY ASSESSMENT AND MODELING: REVIEW AND POTENTIAL APPLICATION IN VIETNAM

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ABSTRACT

This research is an attempt to assess and model biodiversity by calculating the value of Mean Species Abundance (MSA) in the past, present and future as the composite biodiversity indicator in the frame work of GLOBIO 3 model of UNEP. This model is designed to support the policy makers in the assessment of impacts of scenarios and policy of socio-economic development on the biodiversity. Under the coordination of Ministry of Planning and Investment (MPI), and in cooperation of Environmental Assessment Agency (MNP) – Netherlands, GLOBIO 3 model is attempted to apply in Vietnamese context to study the biodiversity and poverty linkage in order to develop one or several biodiversity indicators in the National Indicator Set for sustainable development.

1. BACKGROUND

1.1. Practical need for biodiversity assessment

During the sixth meeting of the Conference of Parties on the Convention on Biological Diversity (CBD), the parties committed themselves to achieving a significant reduction of the current rate of biodiversity loss at the global, regional and national level by 2010 (UNEP, 2002) and World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 recognizes the CBD as the key instrument to ensure conservation and sustainable use of biological diversity. An international-al consortium of UNEP-World Conservation and Monitoring Centre (WCMC), UNEP-GRID-Arendal and the Netherlands Environmental Assessment Agency (MNP) has developed a new Global Biodiversity Model framework (GLOBIO 3) in order to measure and assess the biodiversity as the methodology framework developed to assess past, present and future biodiversity and used in UNEP's reports of Global Environment Outlook 2,3 and 4. Issues that can be addressed with GLOBIO 3 on a regional, continental and global scale include: (i) impacts of human pressures on biodiversity and ecosystems, and their relative importance; (ii) expected trends in mean species abundance (under various future scenarios) and (iii) likely effects of various policy options.

Although the forest cover of Vietnam has been increased in recent years, but in reality, the quality of forest in particular, and the biodiversity in general, are degrading. Therefore, in order to develop new methodology to assess forest quality and/or biodiversity value under coordination of Ministry of Planning and Investment, the methodology GLOBIO 3 is in progress to test and to apply in Vietnamese practice with the objective to study the relationship between biodiversity and poverty, aiming to develop one or more biodiversity indicators integrated into National Indicator Set of Sustainable Development for Vietnam.

1.2. Composite indicator on biodiversity

In the world, the biodiversity has been measured or quantified, directly or indirectly, by many composite indicators, but the most important indicators are : i) Natural Capital Index – NCI; ii) Living Planet Index – LPI; iii) Biodiversity Intactness Index – BII; iv) Mean Species Abundance – MSA; v) Species Assemblage Trend Index – STI; vi) Red List Index – RLI (Ben ten Brink, 2007). In the recent studies of UNEP (MNP, 2006), the indicator of Mean Species Abundance (MSA) has been widely used and considered as an indicator to assess the biodiversity in order to implement the Convention on Biodiversity at global and regional scales (UNEP, 2004) and understood as relative value of remaining biodiversity at present time related to pristine state. In other words, Mean Species Abundance (MSA)

calculates abundance of original species relative to natural or undisturbed state at ecosystem level and represented value from 0% to 100%. MSA can be considered as a measure for the CBD indicator on trends in abundance of selected species (UNEP, 2004) and recently MSA is also applied in UNEP's 4th Global Environment Outlook: Environment for Development, announced by 26 October 2007 (UNEP, 2007).

1.3. Calculation of the biodiversity value through Mean Species Abundance (MSA) in the model GLOBIO 3

The calculation of MSA value in the Model GLOBIO 3 is used to assess the impacts of scenario and socio-economic policy for biodiversity and to support strategy development on biodiversity conservation and sustainable development at global and regional scales and is a chain of analysis models and human impact assessment on biodiversity such as GTAP (*Global Trade Analysis Project and Pressures on Biodiversity)*, TIMER (*The Image Energy Regional Model)* and IMAGE (*Integrated Model to Access Global Environment)* (MNP, 2006). This model looks at factors influencing directly on biodiversity, in fact, assess the driving forces or causes contributing to biodiversity loss (Millennium Assessment, 2003), namely : (i) land use change; (ii) climate change; (iii) nitrogen deposition; (iv) infrastructure development; (v) fragmentation of ecosystems.

2. CALCULATION OF BY MEAN SPECIES ABUNDANCE AS BIODIVERSITY INDICATOR FOR VIETNAM

2.1. Overall methodology for calculation of MSA for the past, present and future

Methodology GLOBIO 3 (MNP, 2006) and CLUE (Conversion of Land Use and Its Effects) developed by Wageningen University (Verburg Peter, 2006) are used to calculate MSA for the past, present and future for Vietnam. Necessary spatial database are needed for MSA calculation are: i) Landuse map, inluding road map; ii) Database for climate change and nitrogen deposition from atmosphere extracted from global models (IMAGE 2.4) applied for region of South-East Asia; iii) Base-line maps such as DEM, Slope, Precipitation, Population Density, Soil.

Main steps used to calculate MSA are described as following:
Step 1: *Reduce and group landuse types to manageable number in order to estimate landuse types for future used by CLUE methodology*.

Based on table of MSA according each land use type, studied by MNP (2006) on GLOBIO 3 and based in definitions of landuse types of the map, especially related to degraded forest vegetation, the MSA value assigned for each land use group applied for CLUE model in Vietnamese context is shown in Table 1.

Table 1. MSA value for CLUE-based land use types

Code	Group	Group name in English	Group name in Vietnamese	MSA value
0	Group 1	Primary forest	Rừng nguyên sinh	0.95
1	Group 2	Slightly disturbed forest	Rừng bị tác động nhẹ	0.80
2	Group 3	Heavily disturbed forest	Rừng bị tác động mạnh	0.55
3	Group 4	Regrowth shrub and bushes	Cây bụi và cây tái sinh	0.45
4	Group 5	Plantation	Rừng trồng	0.20
5	Group 6	Extensive agriculture	Nông nghiệp quảng canh	0.30
6	Group 7	Degraded lands	Đất suy thoái	0.20
7	Group 8	Intensive agriculture	Nông nghiệp thâm canh	0.10

8	Group 9	Residential and urban land	Đất đô thị và khu dân cư	0.05
9	Group 10	Nature	Thiên nhiên	1.00
10	Group 11	Others	Đất khác	0.10

Step 2: *Use CLUE methodology to calculate land use map in the future based on present landuse and developed scenario*.

One of the main requirement of calculating MSA for the future is to „project“ the land use map in the future. Based on the scenario of socio-economic development or national economic development plan (for example, National Socio-Economic Development Plan towards 2020, vision to 2030), the landuse for the future can be projected by using methodology and model CLUE. The nature of model CLUE is to spatially distribute for all land use types for the future based on (i) socio-economic indicators related to land use for specific period in the future; and (ii) economic indicator for each year according different scenarios. This model uses the techniques of spatial analysis in order to estimate the possibility of spatial distribution for each land use type based on the correlation with natural and socio-economic factors with statistical significance and develops the „possibility“ map for this land use type similarly to suitability map for trees and plants used in agricultural applications. After that, the CLUE model can „predict“ the land use maps in the future.

Step 3: Use methodology to estimate MSA for the past, present and future time.

More precisely, the MSA value is assigned to each landuse/landcover type based on the following criteria:

- Definition of each landuse/landcover type of national classification;
- MSA value assigned for each GLS landuse/landcover class described in GLOBIO 3 methodology (MNP, 2006: table 10.2, p174).
- Local expertise to propose MSA value for each landuse/landcover for global landuse/landcover (GLS) in GLOBIO 3 methodology.

2.2. Results of MSA for the past, present and future for Vietnam

2.2.1. *Evolution of MSA value and its pressure factors in Vietnam*

MSA value for 2000, 2020 and 2050 have been shown in Table 2. In general, MSA values as composite biodiversity indicator increase slightly in period 1993-2000, and increase for 0.5% for period 2000-2020, and reduce significantly for about 2.75% in the period 2020-2050.

Table 2. Remaining MSA and its pressure factors contributing to biodiversity loss in Vietnam (%)

No	Remaining MSA and its pressure factors	1993	2000	2020	2050
A	Remaining MSA	26.24	26.34	27.01	24.75
B	Pressure factors				
1	Land use change	54.97	54.11	47.07	43.60
2	Infrastructure development	10.83	12.11	17.66	21.87
3	Fragmentation	3.39	3.33	3.07	2.85
4	Climate change	1.46	1.67	2.75	4.74
5	Nitrogen composition (pollution)	3.11	2.43	2.44	2.19

It notes that for the period from 2000 up to 2050, the MSA value in all regions of the world, including SEA region, according the GLOBIO 3, have tendency to decline. However,

in the case of Vietnam, MSA has tendency to slightly increase from 2000 to 2020. This will be explained by the fact that the large Vietnamese efforts in reforestation have improved the forest cover, i.e. biodiversity value as MSA. The negative pressures, as climate change and pollution still have small effect and less than positive effects of land use change (reforestation) and decreased ecosystem fragmentation.

Although the MSA value is not changed much for different periods, but its pressure factors are changed significantly. The Land use factor, as always plays important role to contribute to biodiversity loss in Vietnam, but has trend to reduce thanks to large efforts of reforestation programs. Fragmentation has also had less effect on biodiversity loss due to rehabilitation of degraded forest areas.

However, other pressure factors have tendency to play more important role. Infrastructure development, in combination with population density effect, for example, is increased from 10.83% in 1993, to 12.11% in 2000 and projected to 21.87% in 2050 (Table 3). Climate change, expected to intensify in next decades worldwide, will increase from 1.46% in 1993 to 4.74% in 2050.

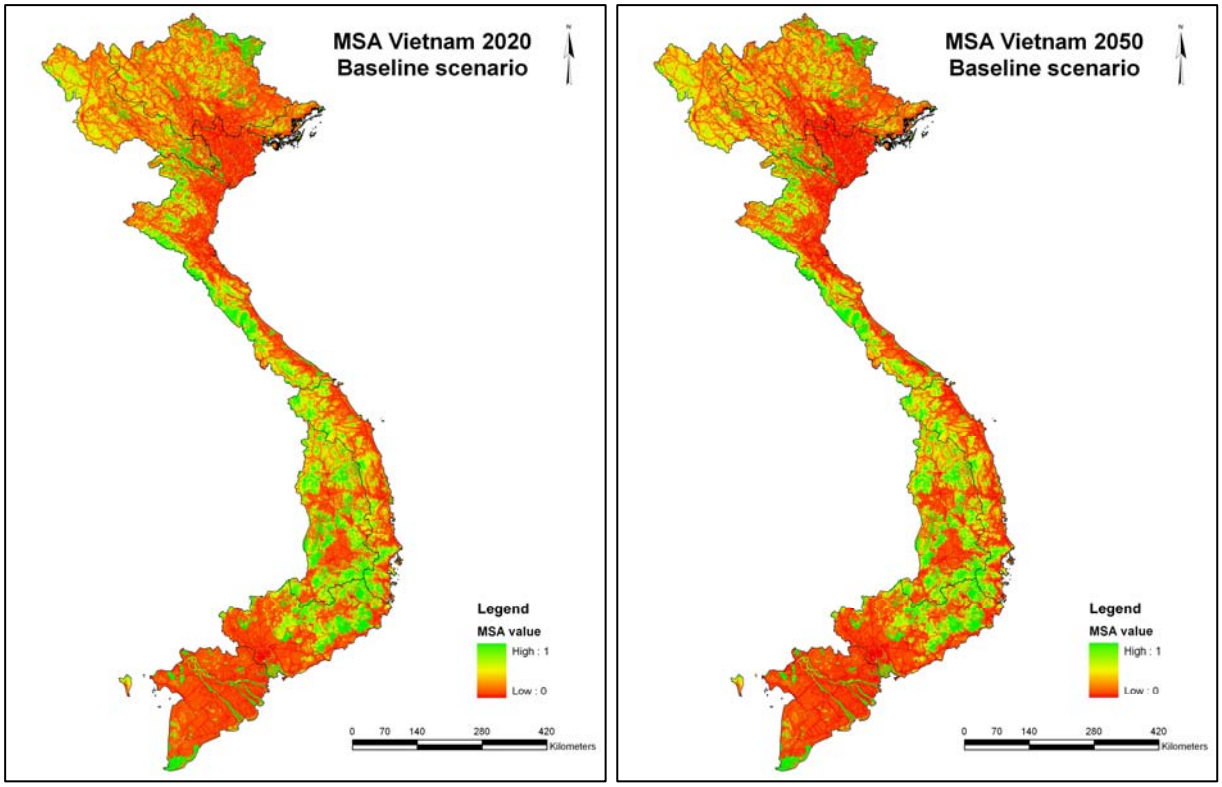

Figure 1. MSA maps for 2020 and 2050 according baseline scenario.

2.2.2. *Evolution of MSA value and its pressure factors by administrative region*

Table 3. Evolution of MSA value by region in Vietnam

No	*Region*	*1993*	*2000*	*2020*	*2050*
1	North West	24.95	24.44	28.31	27.76
2	North East	22.90	22.89	24.14	22.03
3	Red River Delta	13.57	12.35	10.34	8.09

4	Central North	29.64	30.15	29.88	27.68
5	Central South	26.33	29.87	30.08	27.50
6	High Plateau	38.89	37.68	37.85	34.39
7	South East	25.89	24.58	24.74	22.24
8	Mekong River Delta	15.26	16.33	16.66	14.70
9	Whole Vietnam	***26.24***	***26.34***	***27.01***	***24.75***

Although the value of MSA at national scale has not been changed much, from around 26% in 1993 and 2000, 27% in 2020 and decreased to 24.7% in 2050, but these values are fluctuating much more at regional scale. It means that the regions are compensated from each other in term of MSA value. For period from 2000-2020, for example, most regions have neutral trend, but three regions (Red River Delta, High Plateau, South-East) have negative trend. However, two regions (Central South and Mekong River Delta) have strong positive trend that compensate with the loss from three other regions (Figure 2). General trend of MSA for whole country, therefore, is slightly increased.

By analyzing the MSA trend by region, we can recognize which region and when would have problem with biodiversity degradation. Thus, several conservation policies can be applied to certain region to conserve the biodiversity.

Take two regions as example for analyzing the causes of biodiversity loss. North-East is mountainous region and Red River Delta is plain country. Although the trend for mountainous region keeps unchanged untill 2020, and slighty decreased to 2050, but the trends of each pressure is different. Thanks to large scale of reforestation program, forest cover is rapidly increased and therefore the impact of landuse pressure is decreased. Howerer, the pressure of infrastructure developement, in combination of population growth, is significantly increased, so both opposite pressures may compensate each other.

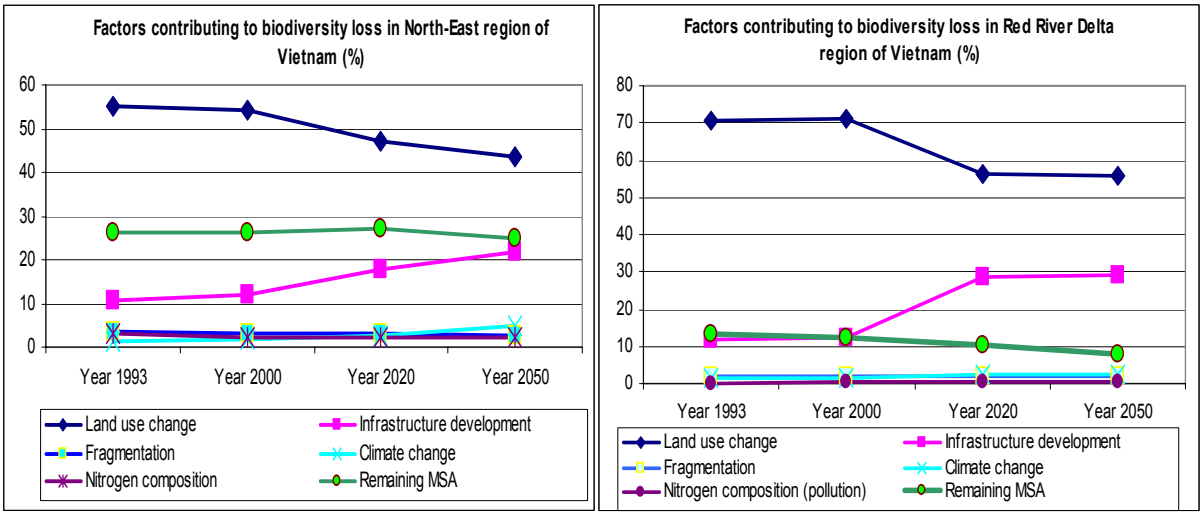

Figure 2. Causes of biodiversity loss for selected regions.

For the plain region, the trend is slowly decreased since 1993 to 2020 and to 2050, but the pressures are quite differentiated. Although the two pressures, in general can compensate to each other, but the negative impact of infrastructure development is higher than positive impact of landuse change, so the result is slightly decreased trend of MSA in

2000-2020. For period 2020-2050, however, all pressures will not have much impact on MSA value.

3. CONCLUSION

- Model GLOBIO 3 and CLUE have been tested for calculating MSA as a composite biodiversity indicator for the past, present and future for Vietnam.
- This methodology can give the consistent results on evolution of MSA values, more or less considered as biodiversity value.
- The results of this assessment have quantified i) remaining MSA/biodiversity value of the terrestrial ecosystem relative to its pristine state and ii) its pressures or causes contributing to biodiversity loss such as Land use change, Infrastructure development, Nitrogen deposition (air pollution), Climate change and Fragmentation of terrestrial ecosystems in the whole country as well as by administrative regions.
- The differences of this methodology are that the MSA shows the biodiversity trend and identify the causes of biodiversity loss in spatial and temporal scales by using the consistent method of calculation.
- This methodology can use the different national scenarios, socio-economic development plans, action plan and strategies to assess the biodiversity in the past, the present and the future in order to help the policy makers adjust this policy to fit more the practical situation. Positive biodiversity indicator (MSA) trend in 2000-2020 is in line with Vietnamese large effort of reforestation.
- Models and methodology to calculate MSA value as a composite biodiversity indicator still have several limitations that should be improved in the future with the objective to help scientists and policy makers the best in the affairs of biodiversity conservation.

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