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Ethno-diversity and bio-diversity: Methods and measurement

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Abstract

Biology and Anthropology/Sociology have dealt with issues of diversity for a long time, developing different concepts, theories and methods. In recent years there has been, if not a convergence, but at least a recognition that problems in nature and in society are interrelated. This paper attempts to use concepts and methods of biodiversity research and test their applicability for a study of ethnic relations. It is noted that the preservation of biodiversity ranks high on the agenda of researchers and politicians, whereas ethnic diversity is often associated with unrest, conflict and economic decline. We try to reverse this tendency by emphasizing social cohesion and the social and economic value of ethnic diversity. An “ethnic diversity index” is proposed and used in the analysis of Malaysia’s plural society. This index is based on Simpson’s diversity index, commonly used in biodiversity research. Further research on the interrelation of bio- and ethnic diversity is advocated.

Keywords: Biodiversity, ethnic diversity, research methods, pluralism, ethnic conflict, cohesion, ethnoscape, Malaysia

Ethnic Diversity



Biodiversity is life
Biodiversity is our life

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1. Introduction: The Concepts Bio-Diversity and Ethno-Diversity

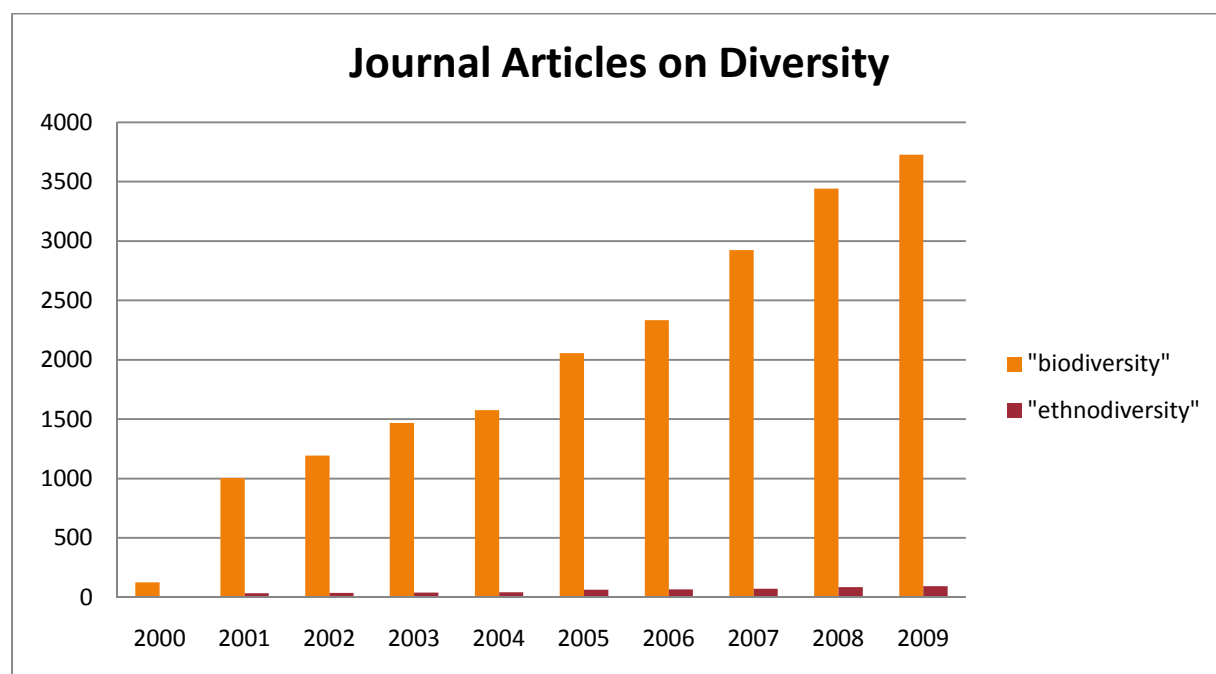
We are living in a world of increasing diversity, both in terms of measurable items, shapes and feature, but also in terms of imagination, thoughts and constructions of reality. A complex array of theories and concepts has arisen to take account of the changes in our real world. The terms we shall be concerned with in this paper are bio-diversity and ethno-diversity.

The concept bio-diversity came into being as recently as 1985 and has since conquered the imagination of scientists, journalists and politicians. The term basically refers to organisms as classified in populations, species, taxa, communities, and other similar categories. It also refers to the composition of ecosystems and evolutionary processes. The term has taken on a strong normative aspect in reference to conservation.

Ethnic diversity or, as it sometimes called, “ethno-diversity” describes the degree of variety of ethnic groups living together on a common territory. There is a very large literature in the social sciences on what constitutes an ethnic group and what binds them together (e.g. the classical study of Barth 1965). Ethnic groups may live together in a “plural society” or form cultural enclaves or “diaspora” in a host society. The issues around ethno-diversity, formerly the domain of social anthropologists, are also frequently taken up by the mass media and by politicians and imbued with a normative tinge, being mostly seen as a burden or a challenge, rather than a boon, especially in nation-building efforts.

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Figure 1 Journal articles dealing with biodiversity and ethnic diversity, as listed in the Web of Science data bank, 2000 to 2009.



If we compare the number of publications on both subjects, bio-diversity is way ahead (see figure 1). As social scientists we could ask the question: what can ethno-diversity research learn from studies on bio-diversity. Either concept, bio-diversity and ethno-diversity are embedded in theories. We shall, however, take up mainly conceptual and methodological issues.

Table 1 Corresponding Concepts of Bio-diversity and Ethno-diversity

Bio-diversity	Ethno-diversity
populations, species, taxa, communities	Ethnic groups, communities, diaspora
Eco-system	Plural society
Conservation	National unity
Sustainability	Resilience
?symbiosis	? cohesion
?	?

Both biodiversity and ethno-diversity research use differently named concepts referring, however, to similar observations and facts (see table 1). Whereas species and taxa are the basic units of analysis in biodiversity research, ethnic groups and communities are the same for ethnicity research. A biologically diverse ecosystem is mirrored by a “plural society”,

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advocating the conservation of an ecosystem is similar to a call for national unity, etc etc. So far the terminology has not been adjusted to match both systems, the biological and the social, despite Durkheim's observation a hundred years ago that "the social realm is a natural realm which differs from the others only by a far greater complexity" (Durkheim 1965{1912} : 31).

Alternative Concepts

Heterogeneity or complexity are concepts close to diversity and are often used to convey the same meaning.

"Heterogeneity refers to the distribution of people among different groups. The larger the number of groups and the smaller the proportion of the population that belongs to one or a few, the greater the heterogeneity is in terms of a given nominal parameter, such as ethnic heterogeneity of a community or the religious heterogeneity of a society" (Blau, 1977:77).

"Heterogenität bezieht sich auf die Verteilung der Mitglieder einer Gesellschaft auf unterschiedliche Gruppen..." (Ziltener, P. (2006).

Geographers have lately given attention to the spatial aspect of biodiversity. The term "geographical complexity" is used to point to this new area of research (see appendix to this paper). The term is generally used to describe the distribution of attributes in space. We shall refer to GIS-based mapping in this context.

2. Bio-diversity and Ethno-diversity as Value and Resource

Since bio-diversity and ethno-diversity have entered the public debate or domain, the valuation of the concepts and the reality behind them has differed considerably. It is difficult to follow all different streams of thought on the matter of diversity, but at least a general tendency is clearly visible. Whereas bio-diversity is valued highly ethnic diversity is not. There is advocacy by NGOs on both issues, but by and large high bio-diversity is seen as important to sustain life on this planet, ethno-diversity is mostly seen as detrimental to social harmony and political stability. The diversity of species is highly valued and the sustainability of nature and mankind has been linked to the maintenance of a high level of bio-diversity. Table 3 contrasts basic concepts and tendencies, albeit in an admittedly rather crude way.

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Table 3 Contrasting Bio-diversity and Ethno-Diversity Research and Policy

Bio-diversity research and policy	Ethnicity research and policy
sustainability	conflict
avoid decrease of diversity	decrease ethnic diversity
value diversity	value unity & lead culture
conservation	ethnic cleansing

In contrast, national governments have stressed national unity, the assimilation of migrant communities and reduction of ethnic identity. Some governments have even gone as far as reducing ethnic diversity by “ethnic cleansing” as a means to create a uniform society. Even policies of affirmative action have a basis in the goal of uniformity rather than diversity. One ethnic community, seen as lagging behind, is supported to bring it up to the same level of (usually economic) standards as other groups. It is hoped that economic and ethnic differences will be reduced, gaps will be closed and diversity will be diminished.



Political leaders generally tend to stress unity (or at least, like in Indonesia and Malaysia, “unity in diversity” (“perpaduan dalam kebelbagaian” in Malay and “bhinneka tunggal ikha” in Indonesian). The “Satu Malaysia – One Malaysia” policy of the Malaysian government stresses the unity of the nation and conveys the message that “we are all Malaysians”, rather than Malays, Chinese, Indians and others. Though this position is debated and disputed, ethnic diversity is still largely perceived as a cause for conflict, disorder and trouble. Thus Shamsul has argued “Kita menolak konsep disunity, yang dianggap negative, dan kita ganti dengan konsep diversity, yang kita terima sebagai sesuatu yang positif. Justru kepada kita,

diversity adalah suatu asset bukan suatu beban semata-mata” (Shamsul 2009:9). It is perhaps significant that even the UNESCO culture report 2000 is entitled “cultural diversity, conflict and pluralism”: diversity and pluralism is mentioned side by side with conflict. Especially political science thrives on conflict and conflict studies. As Shamsul AB (2010:2) has pointed out, “academic and popular analyses on plural societies in Southeast Asia has privileged the ‘conflict approach’...A heavy emphasis has been given to the working of centrifugal forces, which divide, as the ruling societal pattern, and less on the centripetal ones, that encourage convergence”.

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When it comes to bio-diversity the general perception is the reverse. The diversity of species is highly valued and the sustainability of nature and mankind has been linked to the maintenance of a high level of bio-diversity. The reaction of advocates has become quite vocal.

Whereas biological research has, by and large, emphasized the value of diversity, social research (and even more so government planning) has often stressed the potential conflict propensity of multiethnic societies. In the international Convention on Biological Diversity the signatory governments have agreed to take measures to safeguard biodiversity.



The Global Biodiversity Outlook of 2010 shows that the five main global drivers of biodiversity loss are intensifying. These drivers include habitat loss, the unsustainable use and overexploitation of resources, climate change, invasive alien species, and pollution. The report warns that irreparable degradation may take place if ecosystems are pushed beyond their tipping points, leading to the widespread and irreversible loss of ecosystem services that we depend on greatly. Malaysians depend on biodiversity for their prosperity just as much as the inhabitants of other countries. (Statement of the Executive Secretary of the Convention on Biodiversity, National Seminar on Biodiversity, KL 21 June 2010).

The new post-2010 Strategic Plan is expected to have several other key components. These include:

- Drawing strong links between biodiversity, ecosystem services and human well-being;
- Addressing the economic value of biodiversity and ecosystem services;
- Making explicit the importance of biodiversity preservation for poverty eradication and the achievement of the millennium development goals;
- Addressing both the direct and indirect drivers of biodiversity loss, the latter including, *inter alia*, excessive consumption, for example of fossil fuels and meat, population growth, environmentally harmful subsidies, and a lack of public awareness about the harmful consequences of biodiversity loss;
- Promoting concerted action by all by all sectors of government and society in addressing biodiversity loss; and
- Linking such action with efforts to combat and adapt to climate change.

It should be noted that bio-diversity is increasingly linked to social and economic issues. Whether or not biodiversity is in one way or another connected to ethnic diversity has, as yet, to be proven.

3. Linking Biodiversity and Ethnicity Research

We shall discuss several basic concepts of both approaches and then turn to questions of measurement.

The Value of Diversity

Though predictions for the maintenance of biodiversity are gloomy, high values are placed on the maintenance of biodiversity. “Biodiversity is life, our life” is the slogan of the biodiversity convention. Whereas the economic value of biodiversity is stressed, the economic value ethniversity is still not fully recognized. By applying human values to both bio- and cultural diversity discussions in both fields tend to be highly value-laden. Diversity, whether biological, cultural or ethnic should be protected, enhanced and valued. How can we transfer the positive valuation of biodiversity from eco-systems to social systems? In other words what can we learn from biodiversity research in working on plural societies and ethnic relations?

In management theory in contrast to politics the valuation of diversity has meanwhile taken a positive turn. “Diversity management” is supposed to turn diversity into a business advantage. Ethnically diverse teams are deliberately created to increase innovations and improve output. To cite just one example: The Hongkong and Shanghai Banking Corporation HSBC, one of the world’s largest banks, refers to the positive aspects of diversity on its website:

“At HSBC, we believe in the power of diversity. Diversity is central to the HSBC brand. Beyond gender, ethnicity, disability or age, we recognize and appreciate individual differences and how diverse perspectives spark creativity, productivity and performance – that would lead us to progress”.

4. Measuring diversity

The Ethnic Diversity Index (EDI)

The Institute of Ethnic Studies (KITA), Universiti Kebangsaan Malaysia (UKM), is involved in developing a Malaysian Ethnic Relations Monitoring System (MESRA) to track changes in the ethnic composition of the Malaysian population, its livelihood and its political behaviour. Within this framework an “ethnic diversity index” will be developed. It takes its cue from research on biodiversity and related fields. This index will enable policy administrators and civil society organisations to track long-term social change and pinpoint, in combination with other data and indicators, possible fields for policy interventions. The KEDI will be exemplified with some pilot study data towards the end of this paper.

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Singapore City Biodiversity Index

In an expert meeting July in Singapore in 2010 a new index will be proposed. The Index measures "Biodiversity in the City" including factors such as: % of natural/semi-natural areas, diversity of ecosystems, measures of fragmentation of ecosystems, number of native species, proportion of native species (as opposed to invasive alien species), % of protected areas (as "protected areas indicate the government's commitment to biodiversity conservation"). Details of index construction have not yet been revealed.

5. Simpson's Diversity Index

The degree of bio-diversity is usually measured by a statistical formula known as the Simpson Diversity Index Simpson 1947, which shows the probability that two individuals chosen at random from the same area belong to the same species (or ethnic groups)

Simpson's diversity index (also known as Species diversity index) is a measure used to quantify the biodiversity of a predefined area. It measures the number and distribution of each species.

For plants the percentage cover in a square meter or square kilometre is usually used, for animals the number of organisms of a species is counted. The statistical formula for the Simpson index is:

$$D = \frac{\sum n_i(n_i - 1)}{N(N - 1)}$$

Where N is the total percentage or total number of organisms and n is the percentage of a species or number of organisms of a species.

6. Application of the Simpson Diversity Index in Ethnicity Research

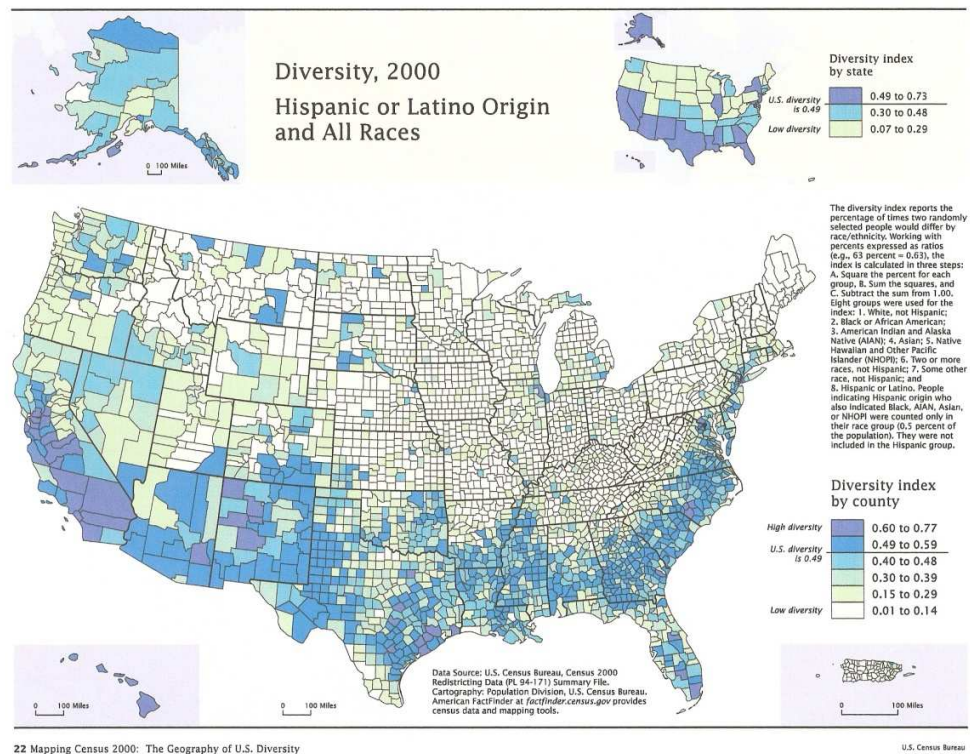
The Simpson Diversity Index can be calculated to show, how the ethnic composition of a nation or district has changed or how different areas compare as to the distribution of ethnic groups.

The advantage of the Ethnic Diversity Index lies in the fact, that large datasets are standardized and can be compared and correlated with other variables. We assume that for instance conflict potential of certain areas is not only related to the incidence of poverty or the dominance of a particular ethnic group, but also to the degree of ethnic diversity. The hypothesis that areas of high ethnic diversity are less prone to ethnic violence than areas of low ethnic diversity can be empirically tested by large data sets. The EDI is therefore both an analytical as well as a planning tool.

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Recently the US Bureau of Census has applied the Simpson Diversity Index to measure ethnic diversity by county (see map below).

Figure 2 Ethnic Diversity, USA 2000



The US diversity index is 0.49. The map clearly shows the areas of high diversity in the South, if persons of Latino origin are counted as a separate ethnic group.

Basic research has just started to link biodiversity and ethno-diversity. The basic idea suggests that man is just one of the many species on earth. Diversity is defined in a broad way to include ethnicity, languages, etc as well as bio-diversity variables.

“Bicultural diversity (BCD) is the total variety exhibited by the world’s natural and cultural systems. It may be thought of as the sum total of the world’s differences, no matter what their origin. It includes biological diversity at all its levels, from genes to populations to species to ecosystems; cultural diversity in all its manifestations (including linguistic diversity), ranging from individual ideas to entire cultures; the abiotic or geophysical diversity of the earth, including that of its landforms and geological processes, meteorology, and all other inorganic

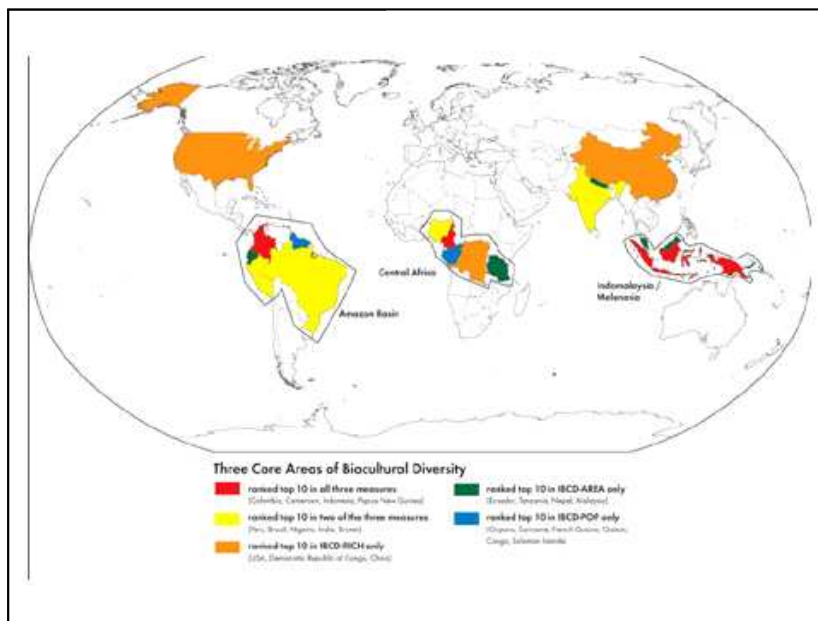
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components and processes (e.g., chemical regimes) that provide the setting for life; and, importantly, the interactions among all of these” (Harmon and Loh 2004:6).

A large-scale research project of Terralingua, conservation NGO, has assembled world-wide data to construct a Biocultural Diversity Index (IBCD). Three components of the IBCD are derived from five indicators of BCD:

- number of languages
- number of ethnic groups
- number of religions
- number of bird and mammal species (combined)
- number of plant species

Figure 3 Biocultural Diversity



Each of the three parts of the IBCD gives equal weight to cultural and biological diversity. Three core areas or “hotspots” of diversity have been identified, one of which includes Malaysia and Indonesia (see map below). Both these countries contain a population that speak many different languages and large areas of tropical rainforests of high but unfortunately fast declining biodiversity. Lipietz (1992) even argues that biodiversity depends on ethno-diversity. It remains, however, unclear why ethno-

diversity should be systematically linked to bio-diversity at all. Further empirically based research will be necessary to establish this link.

7. Ethnoscapes

Ethnodiversity creates distinct, but constantly shifting “ethnoscapes” of ethnic groups, distributed across the geographical space of nations. Appadurai uses a much wider definition that also encompasses many other social categories of people.

“By 'ethnoscape', I mean the landscape of persons who constitute the shifting world in which we live: tourists, immigrants, refugees, exiles, guestworkers, and other moving groups and persons constitute an essential feature of the world, and appear to affect the politics of and between nations to a hitherto unprecedented degree. This is not to say that there are not anywhere

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relatively stable communities and networks, of kinship, of friendship, of work and of leisure, as well as of birth, residence and other filiative forms. But that is not to say that the warp of these stabilities is everywhere shot through with the woof of human motion, as more persons and groups deal with the realities of having to move, or the fantasies of wanting to move. What is more, both these realities as well as these fantasies now function on larger scales, as men and women from villages in India think not just of moving to Poona or Madras, but of moving to Dubai and Houston, and refugees from Sri Lanka find themselves in South India as well as in Canada, just as the Hmong are driven to London as well as to Philadelphia. And as international capital shifts its needs, as production and technology generate different needs, as nation-states shift their policies on refugee populations, these moving groups can never afford to let their imaginations rest too long, even if they wished to” (Appadurai 2010).

In contrast to Appadurai other authors like Smith and Schetter (2005), who define ethnoscape as the territorialisation of ethnic memory, i.e. the belief shared by ethnic groups in a common spatial frame of origin.

We use this term “ethnoscape” in a more restrictive sense, as only ethnic groups are taken into account that do, however, exhibit many of the social characteristics described by Appadurai. Many of the ethnic groups are migrants, there are kinship networks and places of work and leisure, but we emphasize ethnic rather than other social diversities.

8. Towards the Construction of the Ethnoscape of Malaysia

Our main concern in this paper is that the construction of academic and popular analyses on plural societies in Southeast Asia has privileged the ‘conflict approach.’ A heavy emphasis has been given to the workings of centrifugal forces as the ruling societal pattern which divide, and less on the centripetal ones, that encourages convergence. This is perhaps not unexpected in view of the fact that these societies have often experienced internal conflict, struggle and often regime change, mostly traumatic ones. Therefore, the vulnerability and fragility of these societies have been viewed as the main reason why transnational forces, such as global fundamental Islamic activism, find roots rather easily locally. Political analysts often playing the role of ‘prophet of doom’ frequently offer negative predictions about the future of these societies.

It was predicted once that the fall of Soeharto would lead to the breaking down of Indonesian unity as a nation-state. Violence would follow suit and Indonesia would be gone to the dogs. Some suggested that extreme Islamic elements would take over. Others suggested that Indonesia post-Soeharto would become a federal state. Indonesia then, analytically, was at the mercy of the theoretical ‘wolves’ (ready to tear Indonesia as a form of knowledge into bits and pieces) and populist ‘demons’ (ready to demonise anything Indonesian so as to justify sensationally the break-down of the Indonesia social system). It was a kind of a macabre celebration of negativity and violence. A few sane voices such as that of Bob Hefner *Civil Islam: Muslism and*

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Democratization in Indonesia (2000) appears, but the voice too soft to be heard, too lonely to be noticed and too little followers to make an impact.

Malaysia was predicted to suffer from serious bloody ethnic conflicts every time an economic crisis occurred in Asia. After experiencing a series of economic crises in the last three decades, namely, the 1986-87, 1997-98 and the recent 2009-10 economic crises, Malaysia remains politically stable and indeed enjoying a positive economic growth. Admittedly, there have been localized skirmishes, some inter-ethnic and others between social groups, have occurred during this period. However, it did not lead to major bloody conflict outbreaks of a proportion comparable those experienced by Sri Lanka or by some of the Central African countries.

However, this didn't stop Malaysian own political prophet of doom Mr. Lim Kit Siang to republished his book entitled *Time Bombs in Malaysia: 30th Anniversary Edition* (2009, original 1978) as if Malaysia have just had its 30th bloody ethnic riot of the May 13th 1969 magnitude. What many have failed to realize is that all the predictions of the prophet of dooms have not come true. Instead, since the major ethnic riot in May 13th 1969, there has been consistent long peaceful period, punctuated once or twice by ethnic skirmishes. Instead, all the riots and conflict have been happening in the north of peninsular Malaysia, in the once famous 'peaceful' Thailand.

Why didn't the expected conflict take place in Malaysia? This has to be explained.

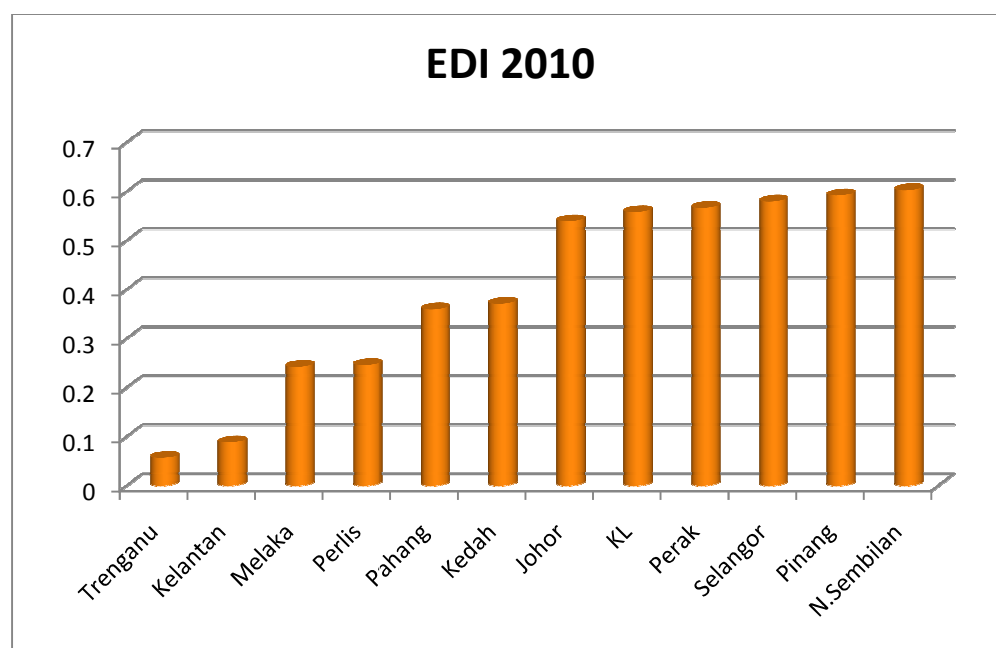
It appears to be more useful to approach this issue sociologically from a 'cohesion approach' with the assumption that the plural societies in Southeast Asia are generally in a state of 'stable tension' meaning they have been surviving in a situation dominated by major societal contradictions but nonetheless, longitudinally, remains generally cohesive. In other words, there is some level of social cohesion within these societies, but the journey has not been plain sailing. Often the social cohesion is punctuated by skirmishes which were resolved quickly.

In other words, if we were to emphasize of the 'negative' aspects of the diversity, which usually involved a small percentage of the population, we are then giving a disproportionate focus on as an aspect of the social reality. As a result, we shall miss the larger portion of the 'positive' aspect of diversity that the general population is enjoying. The moot question is how we shall redress this 'analytical myopia.' For this we should study the experience and empirical evidence from Malaysia and take our clues from biodiversity research and advocacy.

Malaysian states differ greatly in terms of ethnic diversity, even if we only use the broad categories of Malays, Chinese, Indian and others (see figure 4).

Ethnic Diversity

Figure 4 Ethnic Diversity Index, West Malaysia 2010



Source: EDB and own calculations

The index shows that Malaysian states can be grouped in three categories.

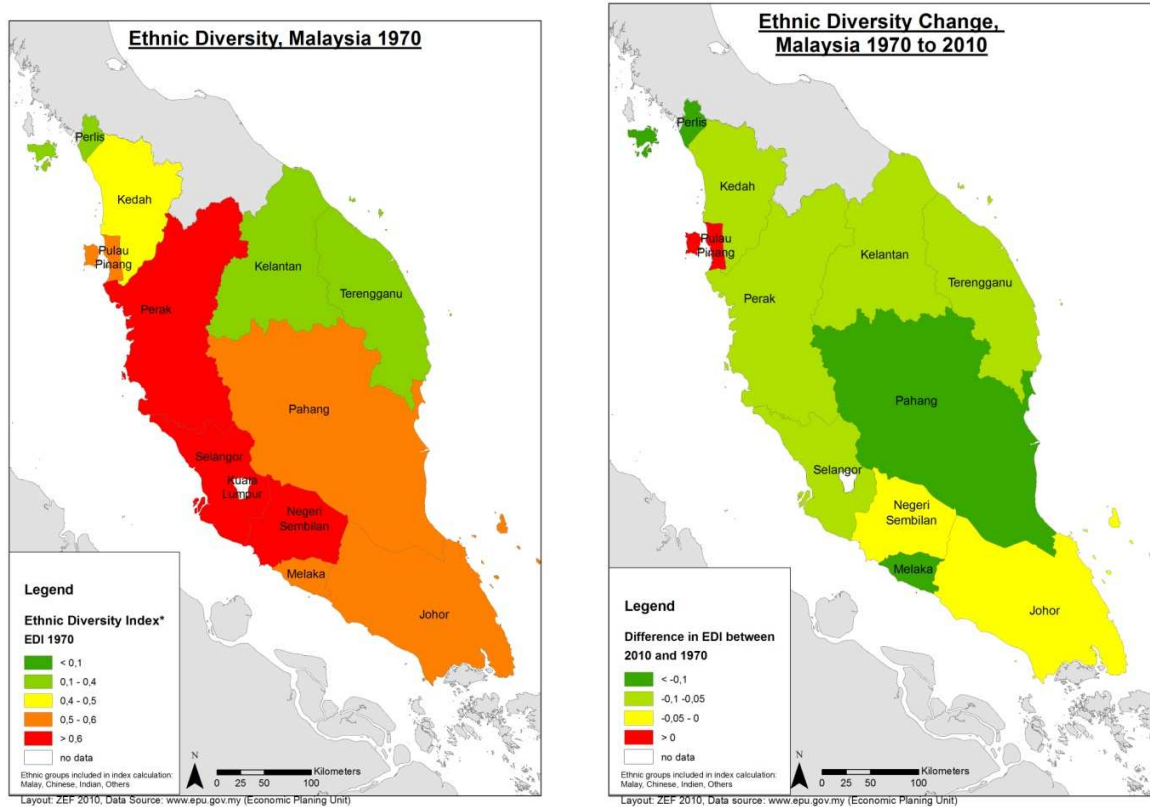
Table 5 Ethnic Diversity Index, West Malaysian States 2000

Ethnic Diversity	States
Very low 0-0.1	Kelantan, Terengganu
Medium 0.2 – 0.4	Perlis, Pahang, Kedah
High diversity 0.5 - 0.7	Melaka, Perak, Johor, Negri Sembilan, Pulau Pinang

The following maps show the changing ethnoscape of West Malaysian states. These maps can be easily explained with reference to the well-known population distribution of the West Malaysian states. More surprising, however, is the change in ethnic diversity between 1970 and 2010. In only one state, namely Penang the ethnic diversity has increased, whereas in all other states, particularly in Perlis and Pahang, ethnic diversity has been reduced. A more detailed analysis will be provided, as soon as data on a district and constituency basis become available.

Ethnic Diversity

Figure 6 and 7 Ethnic Diversity 1970 and Change of EDI between 1970 and 2010

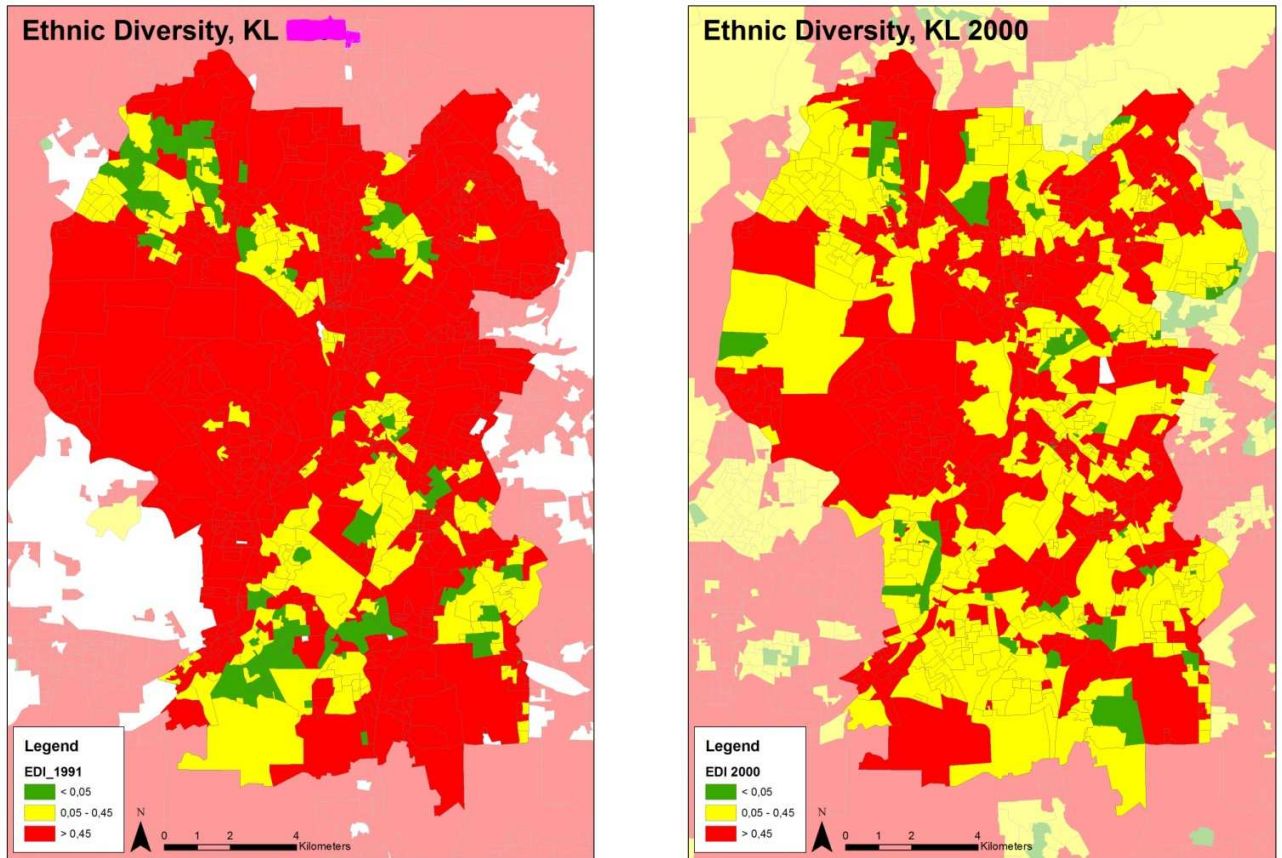


Data: EDB. Map design: Pamela Nienkemper (ZEF, University of Bonn)

Down-scaling the diversity index to census block level yields a much clearer picture of the development of ethnic diversity. The following preliminary maps show the change of ethnic diversity in Kuala Lumpur. If the data are correct, ethnic diversity has declined and living areas have become more segregated. This preliminary result needs further checking and investigation.

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Figure 8 and 9 Ethnic Diversity Index for Kuala Lumpur, 1991 and 2000



The MESRA study attempts to create an “early warning system” of social and ethnic tensions. Prevailing monitoring projects on ethnic relations in the country tend to focus on the negative aspects of these relations such as ethnic-related grievances and the number of ethnic group conflicts taking place. This study uses a positive indicator based on good governance and quality of life indices as a way to understand the level or quality of ethnic relations in Malaysia. A pilot survey of 5 constituencies has been completed and the data are now being analysed.

These data represent the distribution of ethnic groups in five Malaysian constituencies, as shown in the table below.

Ethnic Diversity

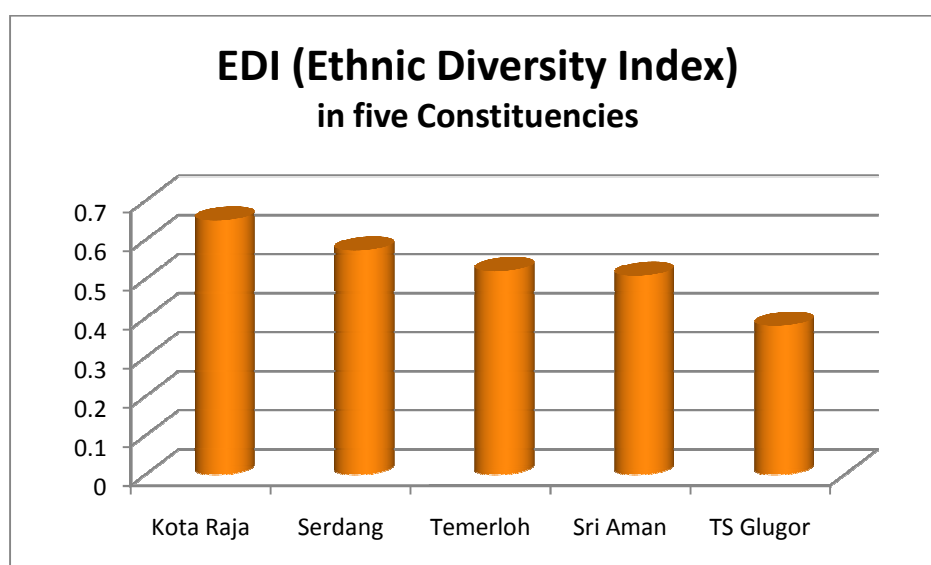
Table 5 Distribution of major Ethnic Groups in 5 Malaysian Constituencies

	<i>Kota Raja</i>	<i>Serdang</i>	<i>Temerloh</i>	<i>Sri Aman</i>	<i>Tasek Glugor</i>
	%	%	%	%	%
Malays	47.8	36	63.4	18.1	77
Chinese	21.3	54.4	26.6	15.8	14.70
Indian	27.6	10.7	8.7	65.9	7.50
others	3.3	0	1.3	0.2	0.80

Source: MESRA. KITA-UKM 2010

The respective EDI (ethnic diversity index, figure 5) shows the differences in the five sample areas.

Figure 5 Ethnic Diversity of Voters in five Constituencies.

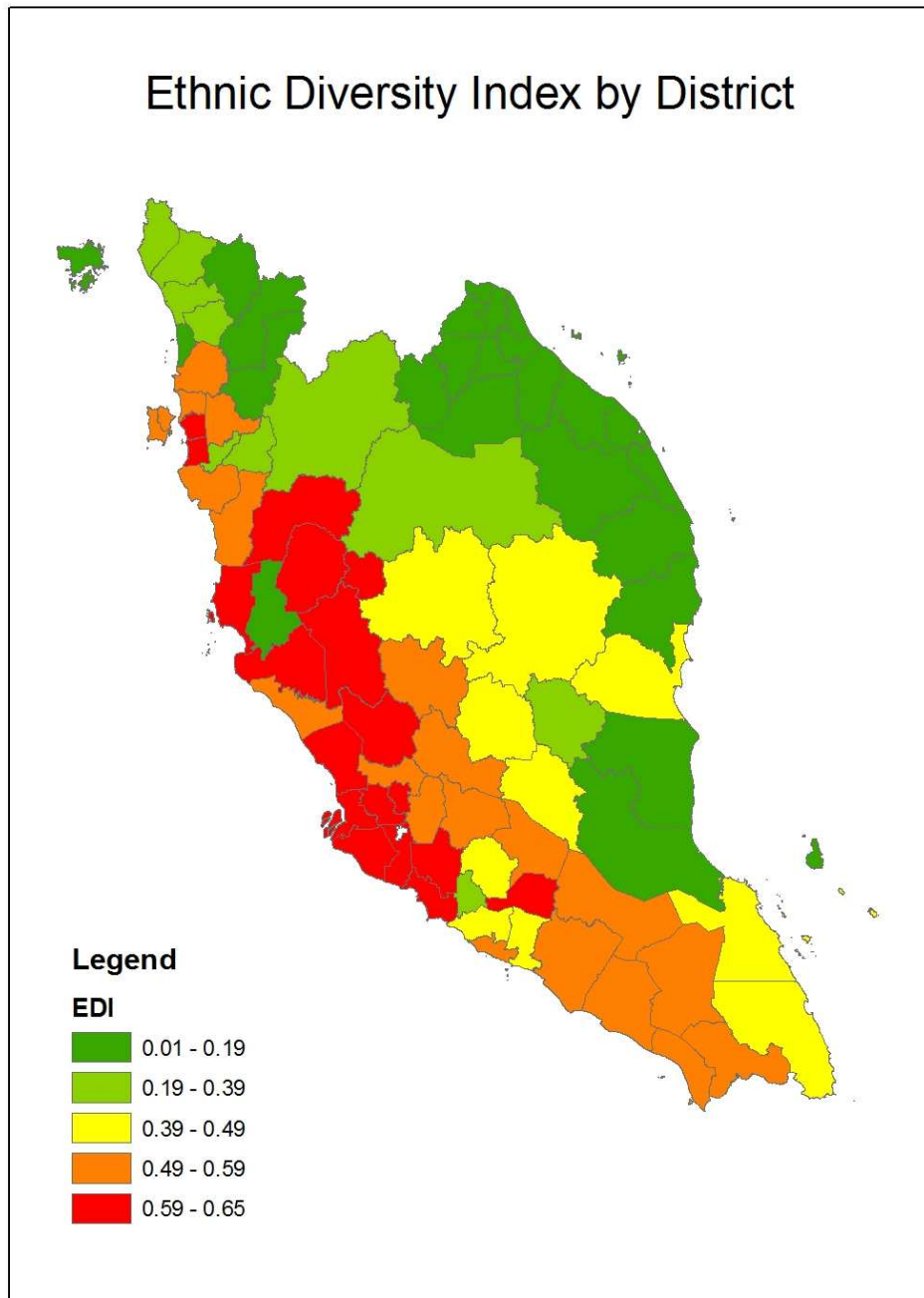


Source: MESRA. KITA-UKM 2010

The following map is a first attempt to show ethnic diversity in Malaysia at a district level. The district data are derived from the Malaysian census of 2000. A detailed analysis is under way and will be provided at a later date-

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Figure 10 Ethnic Diversity Index, West Malaysia 2000 (District Level)



Ethnic Diversity

Map design: Hans-Dieter Evers and Pamela Nienkemper (ZEF, University of Bonn)

Conclusion

The uses of the diversity index have not yet been fully explored. A Pandora's Box has been opened, as there is still scope to address many questions with further research. The Ethnic Diversity Index to be developed by the Institute of Ethnic Studies (KITA), UKM will be

- Based on the Simpson Diversity Index
- Will use data on all Malaysian Parliamentary constituencies or mukim
- Will develop time series 1990-2010
- Will provide correlation with other socio-economic data

The analysis of ethnic diversity will have to rest on the assumption that "ethnic diversity" is a variable in its own right. It treats the all ethnic groups as equal, irrespective of their cultural, social and economic status. As an independent variable it may be correlated with other socio-economic data and enable the researcher to investigate the interrelation between ethnic diversity and development. We hypothesize that ethnic diversity will have a positive impact on innovation, social mobility and economic development. This hypothesis still needs to be tested with empirical data, before any robust conclusions can be drawn.

Although biodiversity differs from social and ethnic diversity, lessons have been learned from biodiversity research, both in terms of methodology as well as concepts and theories. We hope to have shown that cooperation across disciplinary boundaries is likely to open new avenues of inquiry and will yield new results.

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Appendix

Biocultural Diversity Index (BCD)

Ethnic Diversity

A country's overall BCD-RICH score is calculated as the average of its cultural diversity richness score (aggregated from the scores for languages, religions, and ethnic groups) and its biological diversity richness score (aggregated from the scores for bird/mammal species and plant species). The same holds true for BCDAREA and BCD-POP.

Geographical Complexity

Understanding geographical systems represents one of the greatest challenges of our time. Complexity has emerged as a useful paradigm to effectively study linked human, socioeconomic and biophysical systems at a variety of different spatial and temporal scales. As a result, descriptive and predictive models of various levels of sophistication and using mostly agents, genetic algorithms, cellular automata and neural networks are now beginning to regularly appear in the geographic literature. However, there still remains many unresolved conceptual, technical and application challenges associated with these complexity based models.

Conceptual: shared and unique complexity signatures in geographic systems; existing and emerging geographical and complexity theories; epistemological and ontological influences; complexity based model designs; networks and hybrid models; linking classical and spatial statistics in complexity studies.

1. **Technical:** space-time patterns and dynamics; standardizing the development and representation of complex systems; rule selection and implementation; multiple-scale interactions and structure, system evolution and self-organization; learning and adaptation; calibration, validation and verification; path-dependence; non-linearity.
2. **Applications:** effectiveness of complexity models when embedded in political, institutional and socio-economic systems; human-environment interactions; earth systems science; land use science; landscape ecology; sustainability analysis.

Source: Program, Association of American Geographers Annual Meeting, April 14-18, 2010, Washington, DC, USA (<http://gisagents.blogspot.com/2009/09/aag-special-session-modeling-geographic.html> 22-09-09)