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BIO-DIVERSITY AND DEVELOPMENT

S. P. Mukherjee

S.P.Mukherjee was Centenary Professor of Statistics, University of Calcutta and is currently Chairman, Board of Directors, International Statistical Education Centre, Indian Statistical Institute and Mentor, Indian Association for Productivity, Quality & Reliability.

1. Introduction

Bio-Diversity implies the amazing variety of life forms on earth and of their support systems. A whole host of factors has led to the differentiation among the life forms and among the soil-water-air support systems over the ages and a whole of array of activities—some natural , but most anthropogenic—has been posing threats to this mosaic of distinguishing features, and thus to bio-diversity. Some of these activities have led to extinction of some distinct groups or taxa of life forms and of some life-support systems. Some others have caused a gradual or sudden loss in numbers of individuals belonging to some groups or to some classes of eco-systems.

Bio-Diversity is a fundamental building block of sustainable development. It underpins the delivery of a wide range of essential goods and services on which we all depend : food, fodder, fibre and medicines. To poor people inhabiting rural areas, bio-diversity is a safety net a natural health service and an insurance strategy.

Development plans and projects may emphasise on demands for some particular life forms –at the cost of others- to meet resource requirements for production processes to satiate human consumption of goods and services. This emphasis will generally to changes in eco-system diversity and will lead to loss of bio-diversity. To keep in mind the need to provide resources to future generations (which may have different consumption patterns) we should preserve and, if possible, enhance bio-diversity. Of course, conservation versus (economic) development continues to invite debates and. we are all concerned about changes in bio-diversity, linked with climate change.

Many investigations on loss of bio-diversity have linked the loss to problems in ensuring sustainable development and have squarely blamed the ever-increasing greed of humans to consume more goods and services so that a seemingly 'better quality of life' can be enjoyed. This has implied an exponential growth in production and consequently substantial reduction and/ or degradation and even depletion of natural resources which include bio-diversity.

The recent policy of 'planned obsolescence' consciously though discreetly followed by Industry and the growing practice of 'use and throw' adds fuel to the needs of the production system that , in many cases, emphasises on extracting some of its material and energy needs by promoting or enhancing some forms of eco-systems or some varieties of some animal or plant species at the cost of certain others, resulting in a loss of bio-diversity.

While all this is undeniably true, it must be remembered that our planet started losing species diversity much earlier in time before so-called civilised and greedy humans occupied the stage. Many animal species became extinct because they lost out to other species who were more' 'fit for survival' with the limited stock of life-support resources on earth. Thus , loss of bio-diversity has been an on-going phenomenon.

2. Measuring bio-diversity

Bio-diversity can be identified at five hierarchical levels : we can count the number of ecosystems, ecological communities, species, populations, or genes in any defined area. Bio-diversity is usually discussed at three levels *viz*. eco-system diversity, species diversity and genetic diversity . Terms like eco-system and species may not have unique connotations in a discussion on changes in bio-Diversity.. And species diversity and its changes over time with its causes and consequences worries us most.

Eco-systems support life and living organisms. Hence changes in eco-system diversity is strongly linked with changes in species diversity which is the most discussed issue.

Measures of Bio-diversity should take into account loss (extinction) of types as also inequality in the relative abundances of the existing types/classes (taxa). Early attempts to quantify bio-diversity date back to Fisher (1943), Yule (1944), Williams (1948) and Simpson (1949). Measures suggested by Fisher and Yule really indicate the degree of concentration exhibited by a population when its members are classified into a number k of groups. Both are computed from samples. Yule's measure is defined as

$$C = 1000 \sum n_j(n_j-1)/n^2$$

where n_j individuals out of a total of n belong to category j. Extending the idea to an infinite multinomial population with probabilities $\prod_j$, we get the Gini-Simpson index $\lambda = \sum \prod_j^2$ which can be easily interpreted as the probability that two individuals picked up randomly and independently from the population will be found to belong to the same category. The index varies between 1/ k implying the largest bio-diversity and 1 implying perfect concentration. An unbiased estimator for λ is provided by

$$l = \sum n_j (n_j -1) / n(n-1)$$

It can be found that c is asymptotically unbiased for 1000 λ .

These measures really apply to the current distribution of individuals across k sub-types within the same type/ species. It may be noted that k will change from one time period to another.

The general measure of bio-diversity is given by

${}^qD = (\sum p_i^q)^{1/(1-q)}$ the sum running from 1 to R. Here R is Richness (number of types in the data set) and q is the order of diversity. When q tends to 1, this measure goes to exp $(-\sum p_i \ln p_i)$

To comprehend changes in species diversity, Whittaker (1972) argued that total species diversity in a landscape (gamma diversity) is determined by two independent components—the mean species diversity in sites or habitats at a more local scale (alpha diversity) and differentiation among those habitats (beta diversity). Thus scale considerations arise. There is no unique alpha diversity concept.

A measure of species diversity in a given data set (corresponding to a given point/period of time) reflects the pattern of abundance. Larger is the value of such a measure, greater is the chance of some taxa moving towards extinction.

Comparing such a measure for two time periods, we may not be able to quantify the loss of some species in which we remain interested.

A diversity index reflects how many different types (such as species) there are in a data set, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. The value of the index increases both when the number of types increases and when evenness increases. For a given number of types, the value of the index is the highest when all types are equally abundant.

Emphasis is usually laid on loss of species and genetic diversity. However, changes in eco-system diversity affect habitat differences that foster species diversity. In fact, beta diversity is linked up with habitat differentiation. Eco-system diversity has possibly increased (?), through species diversity has definitely gone down.

For any entity like land mass with types corresponding to use (given by land-use statistics), diversity in terms of the number of types has possibly gone up. Some types like grazing pastures might have become scarce, while some new uses and, thus, some new types of land use, have come up. In the case of plants and animals , species diversity has been on the wane through anthropogenic activities and consequent changes in life-support systems. Even for the same plant species like paddy, the number of sub-species available earlier in South-East Asia has fallen sharply. Some varieties were found uneconomical by farmers, based on assessment of gross value added, while others were withdrawn under pressure. Relative abundance of some species like sunflower has grown with newer uses of sunflower for getting edible oil *etc*. Human intervention has led to the development of many hybrid types.

The relative abundance of different types of an entity that can be looked upon as a resource for economic activities has to fit into the production of goods and services as are 'desired' for economic development of a region. This way, economic development may mandate the number of species that should continue to exist and their relative abundance. Conservation versus modification/development has been the subject of never-ending debates. Amount willing to pay for conservation of an eco-system in its pristine form and amount willing to accept as a compensation for loss of services provided by the existing eco-system have been used to strike a balance between conservation and development.

Measuring relative bio-diversity

Measures of Relative Bio-diversity should quantify agreement or divergence between the desired set of relative proportions (of the different taxa) and the current or observed set of proportions, taking due care of types which have since disappeared and those which have surfaced. Measures based on entropy or even Simpson and related indices focus more on equal abundance of different types, which might have never existed nor is currently desirable.

Shannon Index defined as H=-$\sum$plog p summed over all the species/types in the data set measures the difficulty in predicting the species to which a randomly selected specimen will belong and is the highest when the types are equally abundant. When all the types in the data set are equally common, al p_i values equal 1/k and hence Shannon index takes the value lnk .

The Renyi entropy is a generalization of Shannon entropy to other values of q than unity. It can be expressed as

$$^{q}H = 1/\ (1-q)\ \ln(\sum p_i^q\ )$$

Simpson Index defined as $\lambda = \sum p_i^2$ equals the probability that two specimens taken at random from the data set of interest represent the same type. Diversity measured by 1- λ is highest when p_i= 1/k for all i.

Both the measures are invariant w,r,t, the types. None of the commonly used indices take care of loss in the number of types since a reference period *e.g.* pre-industrial revolution era. Measures of distance between the two multinomial distributions—one representing a desired situation or the one prevailing in a given period and the other corresponding to the current situation—are better. The 'base' situation is rather easily taken care of, though records of the different types and their proportions for that period may not be available.

The appropriateness of any measure of species bio-diversity may depend on the level or area covered by the eco-system under study. A high probability of any two randomly selected sample units belonging to the same species may be desirable to take advantage of economies of scale in a particular region that suits a given species and may even rule out others.

Measuring Change in bio-diversity

A good measure of change in bio-diversity can be taken as the Hellinger distance between the two multinomial distributions *viz*. P =$(p_1,p_2,\ldots p_k)$ and Q=$(q_1,q_2,\ldots q_k)$ defined as H^2= ½ [$\sum (p^{1/2} - q^{1/2})^2$]. A related measure of divergence is given by the Bhattacharya distance (Sankhya, 1946).

If in the current state (to be compared against the base or reference situation) some species have become extinct, the distance measure will derive a due contribution from such a species. However, if a new species has been added to the existing stock, we have o be careful in noting its contribution.

The big question is about the desired situation. Do we go by the majority choice of this set or do we carry out comprehensive calculations of the expected contributions to indicators of economic development from alternative uses of natural resources with their attendant influence on bio-diversity and yielding indirectly the set of proportions? In the absence of data, do we focus on robustness of the results that can be worked out in some reasonable manner.

Speaking of sustainable development, we should take note of relations between lifestyles and even food habits with ecosystems and environmental status. Taking for granted the current profile of lifestyles , some ecosystem changes and their impacts on environment, how much bio-diversity can be retained now is not easily answered.

A pattern of human consumption of goods and services implies a corresponding pattern of production which, in turn, can be translated into a set of requirements on natural resources (besides man-made ones) embedded in eco-systems, including biotic ones like flora and fauna in terms of their variety and abundance. This latter set calls for changes in relative abundances of the surviving species/ types as also extinction or near extinction of some species, as also the emergence of new types.

Modelling bio-diversity loss

Modelling Bio-Diversity in the context of sustainable developoment has to start with an accepted measure of Bio-Diversity during a period and to examine changes in ecosystem diversity as also species diversity. These changes can possibly be traced to changes in consumption patterns of humans as also of other animals and consequent changes in production processes and their outputs.

Changes in eco-systems in terms of types and frequencies of eco-systems can be tracked, starting from some delineation of an eco-system. More difficult is to characterise the consumption pattern that itself involves a lot of diversity. And any consumption pattern does not uniquely correspond to a particular production pattern in terms of input requirements from natural stocks.

A recent WHO study mentions that livestock agriculture that sustains non-vegetarian diet is the single largest anthropogenic user of land. The Pacific Institute reports that meat and dairy products consume nearly half of California's water.

Models for species extinction and persistence have been developed for human and animal populations recognizing *demographic stochasticity, environmental stochasticity and variability resulting from natural catastrophies.* The models suggest that there is a threshold population size below which the a population has a high probability of declining to extinction. The existence of such a threshold population helps explain why extinction becomes such a threat when contiguous habitats are fragmented into smaller patches Modelling persistence has to consider seasonal and annual variations in the weather and food resources and variations in the density of natural enemies such as predators and diseases.

3. Concluding remarks

Bio-diversity is crucial for sustainable development — for reducing poverty, creating sustainable livelihoods and helping communities adapt to climate change. However, strategies to tackle bio-diversity loss like establishing protected areas or conservation efforts to to take care of endangered species and habitats , generate few benefits for those poor and vulnerable communities who are in need of them. We need to find innovative solutions to create a balance between needs of the poor and preservation of diversity and abundance of eco-systems and species.

While quantification exercises are needed to prioritise actions and evaluate outcomes, we should remember that data required to derive actionable inputs for such actions are not easily obtainable , specially because often we have to carry out longitudinal studies covering long periods of time. We should interpret measures of bio-diversity and of changes in them over time quite carefully, taking due account of scale considerations. If results are extrapolated beyond the actual observations, species diversity in the sub-units generally gives an under-estimate of diversity in larger areas.

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