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On The Statistical Aspects of Sustainable Development Index in The Philippines

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ABSTRACT

The PSR framework that identifies over 100 indicators of sustainable development is used to screen and reduce the list to 18 core indicators. Principal component analysis was used in extracting 3 indices from 18 core indicators. The validity of the three indices in providing a sufficient assessment of the state of macro-level sustainability in the Philippines is verified using cointegration tests of the indices with the indicators from the long list supporting the PSR framework. Sustainability in the Philippines may be viewed in terms of *Sustainable Economic Activities, Increased Income/Employment Opportunities and Forest Ecosystem Welfare, and Progress of Equity.*

Keywords: Sustainable Development, Pressure-State-Response Framework, Core Indicators, Principal Component Analysis, Cointegration Test.

I. INTRODUCTION

The concept of sustainable development (SD) created interest in the geopolitical arena since the last decade. Policy makers adopted the concept as a desirable goal by nearly all governments worldwide since problems regarding the limited resources have assumed one of the top priorities in developed as well as in developing countries. However, there is a remarkable traffic in definitions. Differences and disagreements arise from the different disciplinary perspectives. The different sectors defined sustainability according to their own motives.

In recognition of the fact that sustainable development is a multi-faceted concept, the World Commission on Environment and Development (WCED), otherwise known as the Brundtland Commission defined sustainable development as " Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

In 1992, Agenda 21 was established at the United Nations Conference on Environment and Development or "Earth Summit" in Rio de Janeiro, Brazil. It serves as a blueprint for sustainability in the 21st century. The focus is on the development of societies and economies by means of conservation and preservation of the environment and natural resources. Agenda 21 asks governments to integrate sustainable development into each national strategies and decision-making process.

The Organization of Economic Cooperation and Development (OECD) developed the Pressure-State-Response Framework (or PSR) in the late 1993. Pressure indicators refer to the underlying forces as well as proximate or direct stresses human society puts on the

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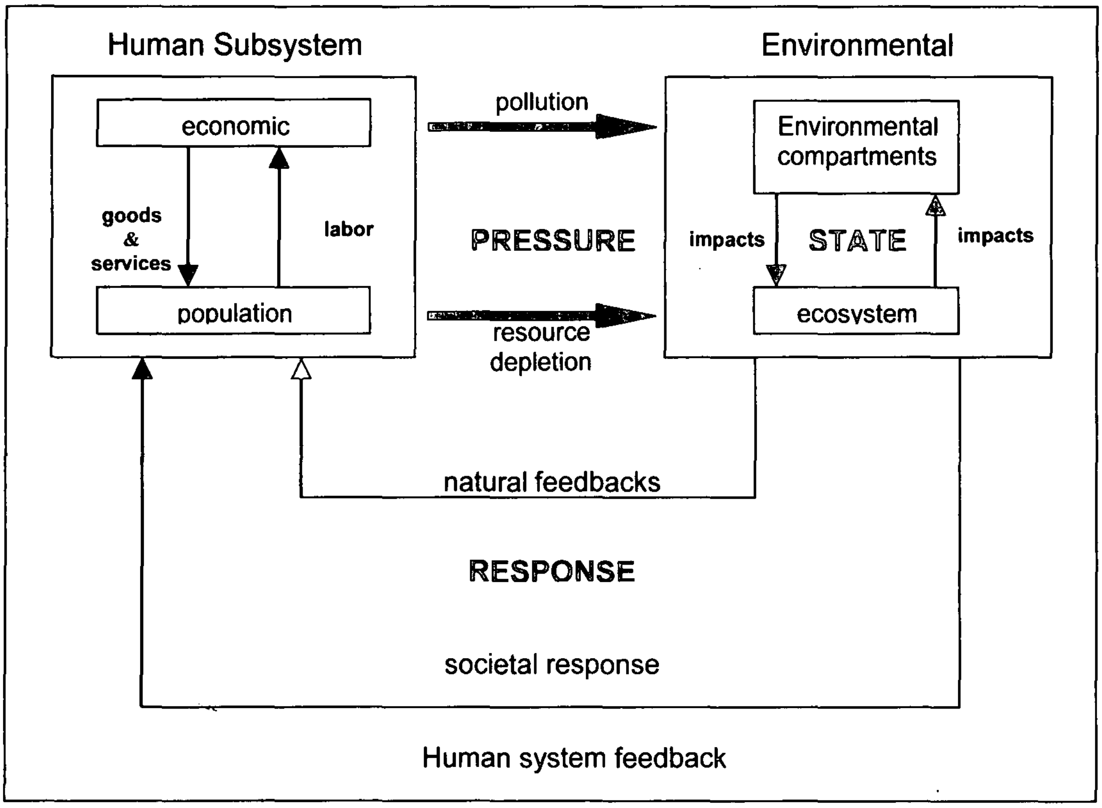
environment. State refers to the condition of the environment that results from human activities or pressure. Response refers to how the society responds to the changes in pressures or state of the environment and these actions are designed to minimize or prevent negative environmental impacts, correct damage already inflicted or to conserve whatever is left of the natural resources. The PSR framework provided a viable tool in the assessment and monitoring of progress towards sustainability. The three components are related in the manner summarized in Figure 1:

Figure 1



Indicators can provide crucial guidance in decision and policy making. The identification of indicators is thus very critical in developing sustainable development indices since this will be the basis for tracking progress towards sustainability. In the latter part of the 1990's the United Nation Economic and Social Commission for Asia and Pacific (ESCAP) implemented a program to trim down the long list of indicators (based on different frameworks) among the countries within the region. The basis of the trimming process includes data availability and validity of the indicators in measuring sustainable development. The resulting "core" indicators should eventually be summarized into indices that can be used in assessing progress in different countries and can provide benchmark for international comparison. The result was a list of 14-20 core indicators of sustainable development across the region.

(Barrios, 1999) short-listed the indicators of sustainable development for the Philippine case. Because of the excessive volume of information, reduction in the number of indicators was done using various statistical techniques like principal component analysis, cluster and correlation analysis.

This study used a relatively shorter list of indicators with data availability during the period 1981-2003. For pressure, a total of 47 indicators were included, with 6 identified to be the core indicators. For state, the 45 indicators were trimmed to 8 core indicators. The limited list of response indicators compelled the use of all four indicators.

The main theme of this paper is the summarization of the core indicators into indices that will facilitate tracking of progress towards sustainability. Since the list is just a small subset of the identified indicators, it will be assessed if indeed, it represents the indicators.

II. DEVELOPMENT OF THE SUSTAINABLE DEVELOPMENT INDICES

The purpose of this paper is to come up with sustainable development indices that would serve as a guide in determining whether a system is moving towards a positive path towards sustainability or not. Principal component analysis (PCA) is used to develop these indices. PCA is chosen since it is a descriptive multivariate analysis tool and robust to sample sizes (annual data covered 1981 up to 2003 is relatively short). PCA is used to summarize indicators of the different facets of sustainable development. This summary produces the indices that show the weights associated with each indicator – the higher the weight, the more informative that indicator is in relation to a particular set of indicators.

The 18 core sustainable development indicators used are grouped as follows:

Economic

GDPCAP	-	per capita GDP
EMPLOY	-	employment rate
GVAAFFP	-	per capita GVA of agriculture, forestry and fisheries

Harvesting Aquatic Resources

FISHQ	-	quantity of fish catch
COMMQ	-	quantity of catch in commercial fisheries
MUNQ	-	quantity of catch in municipal fisheries

Harvesting Land/Forest Resources

IRRIG	-	area irrigated
FERT	-	total fertilizer consumption
CORNY	-	yield of corn per hectare
PALAYY	-	yield of palay per hectare
REFTOT	-	total area of reforestation
REFTIM	-	area of reforestation among timber licensees
FORRES	-	area of forest land for reservation

Air Quality

VEHICLE	-	number of LTO-registered vehicles

Gender Sensitivity

EMPFEM	-	percentage of females employed

Health and Education

EDUCSP	-	government spending on education
HEALSP	-	government spending on health
DIARR	-	incidence of diarrhea

The 18 core indicators exhibit high correlation coefficients justifying the simultaneity of all the variables. This implies that all the indicators actually measure similar concept, that is, all are measures of sustainable development.

From the 18 core indicators of sustainable development, the first three eigenvalues account for 81.29% of the total variability. This means that 3 components will suffice in describing the level of sustainable development. The three components are labeled below:

SDI1: *Sustainable Economic Activities.* This component is comprised of GVA for agriculture, fishery and forestry, indicators on harvesting aquatic and land resources, air quality, and health and education all contributing positively at almost similar levels. The indicator *percentage of female employed* is part of this index but with a relatively lower contribution. Provision of basic social services like health and education can bring sustainable economic activities. A healthy and educated labor force can indicate a strong and stable economic base. Harvesting of resources that is not sufficiently complemented by basic social services is not sustainable since the human capital can easily deteriorate affecting the economic activities.

SDI2: *Increased Income, Employment Opportunities and Forest Ecosystem Welfare.* The component is dominated by income accounts and employment rate as well as area forested. These contribute positively to the index.

SDI3: *Index of Equity.* Incidence of diarrhea has the highest load in this component followed by municipal fish catch. A low incidence of diarrhea would mean people have equitable access to basic health and social services in their barangay. Increased municipal fish catch can be attained through the technology transfer via dissemination of efficient catching technologies, efficient coastal resource management, among others, all pertain to equitable access of productive resources. Other indicators like reforested area, reforested area among timber licensees, yield of palay per hectare and area irrigated also contribute to this index, all indicating equity.

III. ASSESSING THE VALIDITY OF SDI

A cause-and-effect relationship may be confirmed if two or more time series drift along the same direction or the movement of one is parallel to the other. Similarity of movements of the trend would suggest parallel movement of the series. Cointegrated series are believed to affect one another. The cointegration test is important in the assessment of the validity of the derived sustainable development indices. The Engle-Granger methodology of cointegration testing as outlined by (Enders, 1995) are given as follows:

Step 1 : *Pre-test the variables for their order of integration. If they have different orders, then it means that they are not cointegrated. Step 2 may be done only if the variables have the same order of integration.*

Step 2: Fit the model

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t$$

and compute for the residuals.

Step 3: Construct another regression model through the origin with first differenced computed residuals as the dependent variable and the lagged (first order) values of the computed residuals as the independent variable. Rejection of the null hypothesis that the regression coefficient is zero implies that the series from where the residuals were computed are cointegrated.

From the long list of pressure indicators, 11 are cointegrated with SDI1, 19 are cointegrated with SDI2, and 18 are cointegrated with SDI3. Among the state indicators, 12 are conintegrated with SDI1, 12 are cointegrated with SDI2 and 24 are cointegrated with SDI3. Most of the response indicators are cointegrated with the indices. The validity of the three SDI indicators to summarize the list of pressure, state and response indicators is guaranteed by having most of these indicators cointegrated with that of the SDIs. The fact that the SDIs move along the same path as those of the original list of indicators from the PSR framework warrants the usefulness of the indices in monitoring and assessment of the state of sustainable development less the complexity of monitoring a large volume of indicators.

IV. DISCUSSIONS

The use of PCA in summarizing a list of indicators into indices is illustrated in this paper. While the results seem to be statistically and conceptually valid, some issues arise during the implementation. First, is the limited number of observations for a large number of indicators of sustainability. The notion of sustainability has been conceptualized not too long ago hence, the time series for certain indicators are not yet available. Second, when the time series are all or mostly stationary as in the case here, the dimension-reducing character of the PCA may not be attained since the indices may just drift simultaneously along the same direction. Consequently, the indices are not necessarily mutually exclusive, making the interpretation more complicated. In this case, other techniques of aggregation or modifications to principal components like the use of constraints (Zou, et. al., 2004) that will induce sparseness on the loadings may be considered.

Cointegration testing is one important tool that can help in ensuring that the indices are indeed representative of the list of indicators. Issue of short time series data can be explored further as this will be an emerging problem associated with the indexing procedure.

V. CONCLUSIONS AND RECOMMENDATIONS

From over 100 indicators of sustainable development based on the PSR framework, principal component analysis and cointegration testing are used in the development of sustainable development indices (SDI) as well as in ascertaining its validity and consistency. From the 18 core indicators screened from a previous study, three indices are extracted: *Sustainable Economic Activities; Increased Income, Employment Opportunities and Forest Ecosystem Welfare; and Index of Equity.* The indices being cointegrated with most of the basic indicators guarantee their validity in summarizing/aggregating the list of indicators of sustainable development. When assessment of the state of sustainability of the Philippines at the macro level is needed, only 18 indicators will have to be collected and the three indices computed.

The utility of the resulting indices may be expanded if relevant statistical and economic issues can be threshed out further. First, on the statistical side, issues on statistical inference for the index score from principal component of time series data need further consideration. If the index score moves a specific magnitude, it is important to know if such movement is significant so that the crucial adjustments on the policy instruments can be made to foster a significant movement of the economy towards sustainability.

In the economic side, the interpretation of the indices may encounter some ambiguity since issues are imbedded into the index especially for SDI2. This economic problem though might be brought by the statistical phenomenon of the raw indicators being non-stationary and hence, drifting away altogether in the same direction. As a consequence, the principal component may just result to an averaging of the indicators, failing to yield the dimension-reduction objective it aims to attain. One possible solution is to apply a method that will yield sparse loadings to the components.

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