Global Journal of human-social science: b
Geography, Geo-Sciences, Environmental Science & Disaster Management
Volume 21 Issue 4 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-460x & Print ISSN: 0975-587X

Local Sustainability Model based on Sustainable Harmonic Movement Analysis

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GJHSS-B Classification: FOR Code: 269901

Strictly as per the compliance and regulations of:

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I. Introduction

In the vision of directing the development of man (UN, 1987) established the scope of Sustainable Development[1] alternative to economic development, its foundation being the sustainability that has as a premise ¨satisfying the needs of the present without compromising the capacity of future generations¨, guaranteeing the balance between economic growth, the environment and social well-being. Likewise, the Sustainable Development Goals (UN, 2015) have been established, which prioritize and lead to the consideration of new actions to confront poverty, protect the planet and improve the lives and prospects of people in the world. Currently as an alternative to develop economic activities oriented to the SDGs.

Local Sustainable Development is based on the concept of endogenous local development that grants a predominant role to companies, organizations, local institutions and civil society itself, identifying the economic dimension that allows local entrepreneurs to improve competitiveness, the social dimension and the institutional dimension and the basic values of the development process. (Stöhr, 1985). The vision of local economic development in addition to economic development in general, are added the fields of analysis of natural capital, social capital, importance of institutional strengthening, promotion of the participation of local communities, human capital, by improving access to education, nutrition and health, the role of women, the innovation needs of each territorial productive system in context, competitiveness, economic globalization and the assessment of environmental sustainability (ECLAC, 2011).

II. Sustainability Model

The Local Sustainability Model (LSM) is conceptualized within strategic planning (Ander, 1995) with the purpose of highlighting the importance of current policies and interaction of social actors. This is how the LSM is characterized by being dynamic, highlighting in the methodology the contribution of the opinion of experts, who have a scale of values of what is convenient and not convenient in the objective of finding Economic, Environmental, Social and Governance Sustainability[2] necessary for develop the model. The beginning of the evaluation of the problem is established with the baseline which includes the regulations and specifies the normative planning. The Sustainability Model is articulated at the strategic level with what it can be and at the operational level with the desire to make a flexible scheme. Thus, in a first stage, the selection of indicators is determined from a cause/ effect model or an analytical approach (Glave et al., 1995) and then they are subjected to the logic in the construction of the model, evaluating the indicators. In a second stage, the indices for each proposed model are dimensioned and interact.

The conceptualization of the LSM is established through the relationship of variables between the definition of Local Sustainable Development (LSD) and

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[1] The definition of Sustainable Development is established according to the Rio Declaration 1992.

[2] According to the Earth Summit, Johannesburg 2002 the 4th component of Sustainability was established as Governance. In this scope, its correspondence with Institutional Sustainability is considered.

Sustainable Local Development for activities (SLD^{Ai}) referring to the following relationship.

$$LSD = SLD^{A1} + SLD^{A2} + SLD^{A3} + \ldots\ldots + SLD^{An}$$

$$LSD \approx SLD^{AX}$$

$$SL = \mathbf{B}(S^{AX})$$

Involving the advance of other economic activities in the local geographical area, with which in this context Local Sustainability is measured in function to Activity Sustainnability by the following recursive equation:
Where:

B: Between 0 and 1
B = 1 greater predominance of activity X

Having,
$S^{L} = f(S^{L}_{E}, S^{L}_{S}, S^{L}_{A}, S^{L}_{I})$
$S^{AX} = f(S^{AX}_{E}, S^{AX}_{S}, S^{AX}_{A}, S^{AX}_{I})$
In unambiguous correspondence there is:
$S^{AX} = f(S^{AX}_{E}, S^{AX}_{S}, S^{AX}_{A}, S^{AX}_{I})$
The following relationship is established in a matrix:

$[S_i^L] = \mu\,[S_{ij}^{AX}].\,[S_i^L]$ (i)
For i=j i=1,2,3,4
Where:
$[S_{ij}^{AX}]$: Sustainability Matrix

III. Sustainability Indicators

The Indicators of the Local Sustainability Model are represented in the Sustainability Matrix, which represents the relationships between the Economic, Social, Environmental and Institutional Sustainability indicators of the proposed activity X. These are:

Economic Sustainability Activity X = S^{AX}_{E};
Social Sustainability Activity X = S^{AX}_{S}
Environmental Sustainability Activity X = $S^{AX}_{A;}$
Institutional Sustainability Activity X = S^{AX}_{I}
Local Economic Sustainability = S^{L}_{E};
Local Social Sustainability = S^{L}_{S}
Local Environmental Sustainability = $S^{L}_{A;}$
Local Institutional Sustainability = S^{L}_{I}

From the relationship established in (i) for Local Sustainability and the Sustainability of the proposed local activity, we have:

$[S_i^L] = \mu\,[S_{ij}^{AX}].\,[S_i^L]$ (i)
$[S_i^L] = \mu'\,[I_{ij}^{AX}].\,[S_i^L]$
$[S_i^L] = \mu''\,[I_{ij}^{AX}] / \|I_{ij}\|.\,[S_i^L]$

Being: $\|I_{ij}\|$ the largest scalar value for Iij, with i = j
and

$[I_{ij}^{AX}]$: Matriz de Sostenibilidad de Indicadores
$[I_{ij}^{AX}]/\|I_{ij}\|$: Matriz de Sostenibilidad de Indicadores Normalizada

The Normalized Sustainability Matrix is constructed from the division of the largest scalar value for $\|I_{ij}\|$ where Iij, with i = j, thus characterizing that the trace will take the Optimal value of 4 which represents the ideal Indicator Sustainability for LSM.

IV. Materials and Methods

The research was based on the praxis developed of the construction of an LSM for artisanal gold mining activities in southern Peru (Gonzales, 2019), and is based on the use of the Canvas and Dolphi Methods, for the determination of objectives and goals, expert opinion and Dynamic Programming techniques for logical sequence and statistical analysis withthe Friedman statistician with p value that allows to identify the sustainability indicators and indices and their dimension to the activity and availability of the resource to later build the Description Sheets of Sustainability Indicators associated with their dimensionality and then submit them to the analysis of the Sustainable Harmonic Movement (SHM) in order to evaluate the optimal MSL of Indicators.

Table N°1: Models and Index

Sustainability Index	$I^{E}MA$	$I^{A}MA$	$I^{S}MA$	$I^{I}MA$
Model	340	340	340	340
Model 1	85	85	85	60
Model 2	85	85	85	70
Model 3	85	85	85	80
Model 4	85	85	85	90

Table N° 2: Description Sheet of Sustainability Indices

Sustainability Index	Index	Model 1	Model 2	Model 3	Model 4
Economic	$I^{E}MA$	0.27	0.26	0.25	0.25
Social	$I^{A}MA$	0.27	0.26	0.25	0.25
Environmental	$I^{S}MA$	0.27	0.26	0.25	0.25
Institutional	$I^{I}MA$	0.27	0.22	0.24	0.26

V. Analysis and Discussion of Results

Based on the results of the AGMA research supported by the operational dimensionality of the activity of 340 participants, the SHM analysis was carried out based on the AHM[3] iteration relationship, finding the following data shown in the Description Sheet of Sustainability Indicators. The established indices are: Economic Indicator I^{E}_{MA}, Social Indicator I^{S}_{MA}, Environmental Indicator I^{A}_{MA} associated with Training and the Indicator Institutional I^{I}_{MA} Institutional Indicator, associated with Business Risk. See Tables N°1 and N°2.

Using the Adapted Holzer Method (AHM)[4] the natural frequencies of sustainability were determined under the condition initial unit S value, and iterated through the following relationship:

$$S_i = S_{i-1} - (w^2/k_j) \sum_{1}^{i-1} I_j.S_j$$

Where:

Sustainability Displacement (S)
Sustainability Frequency (W)
Frequency of Natural Sustainability (Wn)
Sustainability Constant (K) y Sustainability Indicator (I)

Iterating the AHM equation for each model built based on the dimensioned indices for 340 participants in the LSM we have the tabulation of w and the obtaining of w_n for 04 dimensioned models. See Figures N°1, N°2, N°3 and N°4.

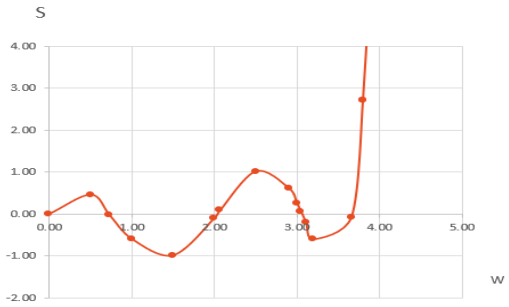

Figure N°1: Tabulation and Graph Model 1

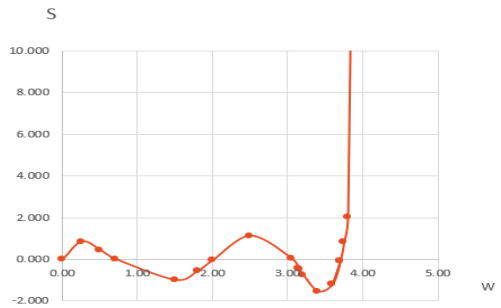

Figure N°2: Tabulation and Graph Model 2

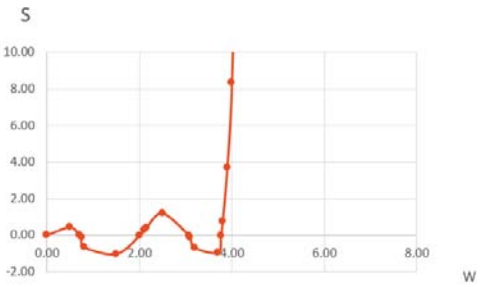

Figure N°3: Tabulation and Graph Model 3

[3] The Sustainable Harmonic Movement (MAS) is defined in reference to a physical system of masses subjected to the Oscillatory Harmonic Movement for the sustainability components.
[4] The Adapted Holzer Method (MHA) is based on the adaptation of the solution of the mass motion equation by the Holzer Method submitting the 4 Sustainability components.

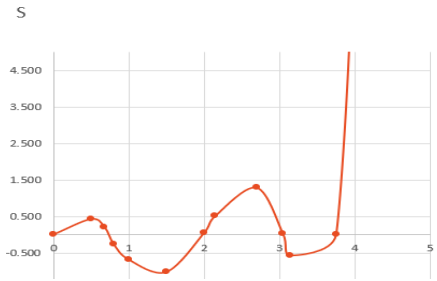

Figure N°4: Tabulation and Graph Model 4

From the graphs, the natural frequencies of sustainability are determined and are presented in Table N°3. Likewise, the tabulation of Sustainability Frequencies complies with the Variation and Trend Tests of Natural Sustainability Frequencies. See Table N°4 and Figure N°5.

Table N°3: Natural Frequencies of Sustainability

Natural Frequencies by Sustainability Model		Model 1 Wn	Model 2 Wn	Model 3 Wn	Model 4 Wn
Economic	$I^E MA$	0.73	0.70	0.70	0.70
Social	$I^A MA$	2.07	2.00	2.00	2.00
Environmental	$I^S MA$	3.05	3.05	3.08	3.05
Institutional	$I^I MA$	3.66	3.70	3.76	3.76
Sustainability Condition		Acceptable	Acceptable	Acceptable	Acceptable

Table N°4: Variation of Natural Frequencies of Sustainability

Relative Variation of Wn	Model 1 Wn	Model 2 Wn	Model 3 Wn	Model 4 Wn
Wn2- Wn1	1.34	1.30	1.30	1.30
Wn3- Wn2	0.98	1.05	1.08	1.05
Wn4- Wn3	0.61	0.65	0.68	0.71
Sustainability Condition	Acceptable	Acceptable	Acceptable	Acceptable

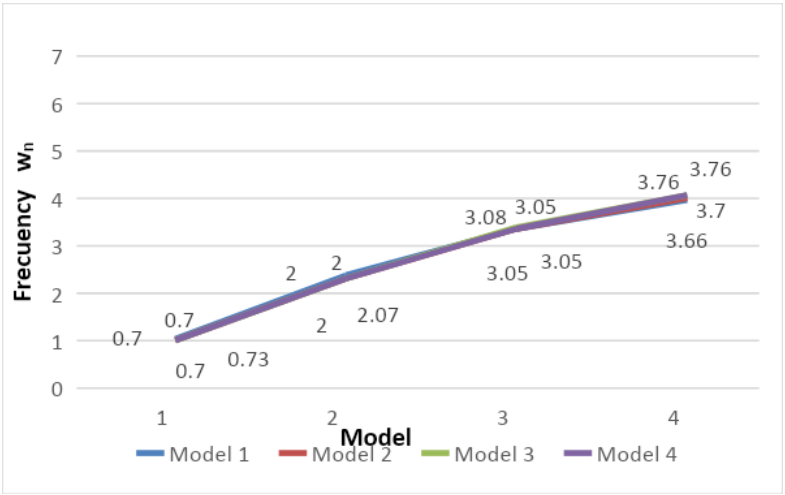

Figure N°5: Sustainability Natural Frequencies Trend

The Sustainability Matrices H_i and their normalization are as follows:

$$\mathscr{H}_1 = \begin{pmatrix} 85 & 0 & 0 & 0 \\ 0 & 85 & 0 & 0 \\ 0 & 0 & 85 & 0 \\ 0 & 0 & 0 & 60 \end{pmatrix} \Rightarrow \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0.71 \end{pmatrix}$$

$$\mathcal{H}_2=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&70\end{pmatrix}\Rightarrow\begin{pmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&0.82\end{pmatrix}$$

$$\mathcal{H}_3=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&80\end{pmatrix}\Rightarrow\begin{pmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&0.94\end{pmatrix}$$

$$\mathcal{H}_4=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&90\end{pmatrix}\Rightarrow\begin{pmatrix}0.94&0&0&0\\0&0.94&0&0\\0&0&0.94&0\\0&0&0&1\end{pmatrix}$$

The Local Sustainability Model (LSM) for AGMA represented by the Sustainability Matrix H_3 presents a Trace equal to 3.94, which represents the optimal model.

VI. Conclusions

- The Sustainable Harmonic Movement (SHM) analysis of dimensioned sustainability indicators based on the Adapted Holzer Model (AHM) allows establishing the optimal Local Sustainability Model based on the Environmental, Social, Economic and Institutional Sustainability components of the proposed activity.
- The Local Sustainability Model based on the AGMA enables the construction of other Local Sustainability Models for other activities based on the SHM analysis, for which the value of **B** must be determined in the recursive equation.
- Given the applicability in the construction of the Sustainability Model, the MAS analysis can be established as an evaluation and measure of sustainability in its components, serving as an instrument in decision-making.

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