FACTOR MODEL OF REGENERATIVE CITIES

Abstract

In the wake of the inability of the present approaches to address the urban challenges, it is replaced by the regenerative paradigm which has the capacity to holistically resolve the issues starring starkly at mankind. As cities continuously use the natural resources they are faced with the challenge to find methods to help regenerate the natural systems. We attempt to propose a factor model that addresses the dynamism of the symbiotic relationship of the urban with the natural environment and one that aligns the human goals with the larger economic, social and environment systems. The methodology adopted was based on people participation that seeks to define the ways of thinking as well as the context based tangible actions. Factor analysis was the statistical technique used (1) Factor analysis based on the principal component analysis method using the software XLSTAT 2021.1.1.1089 - (2) Construct a factor model of Regenerative cities . (3) Interpret and label the factor dimensions. The results of the analysis indicated that the first two principal components accounted for 47.29% of the total variance of the original dataset. Almost all variables were positively correlated to each other and contributed well to principal components PC1 &PC2. The observations were not so well clustered; as there were a few outliers. The model developed is made up of eight characteristic features with each character made up of two parts. One is the gross, ever undergoing changes and the other is a relatively subtle slow changing entity. Both are intertwined, inseparable and seem to be one entity even though they inherently work as two separate entities. This partnership of restorative relationship emerged as the key organizing principle for urban operations. The limitation of the work was that people participation was represented as students well versed with the subject matter.

Keywords: dimensionality reduction, community participation, factor model, variables, Regenerative cities.

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I. INTRODUCTION

The increase in population of mankind led to increase in the economic production with a mechanistic worldview of fragmented approach to the design of cities. With this concept, simplified component design, easily replicable and manageable linear solutions with uniform patterns and typologies destroyed the unique and complex relationships of the physical, social and environmental context of the cities. [1] For instance, the aspect of sustainability found in the water supply component of the eight components of AMRUT – a government of India program launched in 2015, supported the development of lakes for drinking water purpose only. [2] This limited the role that the urban lakes could play in the regulation of urban floods and aspects of biodiversity. Similarly the wastewater-recycling and use component encouraged the increased financial support for conventionally engineered high cost, disruptive solutions as against cost effective nature based contextual solutions. In the recent decades, the term sustainability as defined by the emerging technologies focused on buildings and urban systems based on the operational performance parameters. The built environment was considered as the endpoint of design process and not as a system that will survive by revival of itself over time. As a result cities with miniscule relationship to their surroundings emerged. The concept of sustainability as practiced today seems to lose its credibility in the wake of the call for the novel concept of regenerative development. [3] The acknowledgement of the unobvious relationships of the cities as part of larger regional systems, ceased to make the city an independent operational entity. It paved the way for the Regenerative development approach to the design of cities, which not only allowed for change, but integrated and guided changes that led to better levels of well-being and that which positively contributed to the earth's living systems and processes. [4] This practice that established the link between people and nature based itself on the natural functions of the thriving ecosystem for rejuvenation. Given the wide variety of ecosystems in a country like India, the environment-human relationship needs to be rethought of and established. The fact that the complexity of the environment is incomprehensible, hence the present fragmented approach to urban context at all levels of design and management need to converge into a holistic one, that is subservient to the environment and that which weaves itself with natural systems.[5] This eliminates the present short term vision and patchwork methods at all levels of planning and administration. Fostering regenerative development implies initiating physical, economical, social and environmental strategies for reviving and enhancing the relationship between the cities and their hinterland land which provide resources for the cities survival.[6] People's views, understanding and their needs portrayed with a limited number of characteristics or a reduced number of defined variables by participatory process ensure efficient integration in the planning process. [7]

II. METHODOLOGY

People participation initiatives attempt to find out the understanding and the needs of the people in urban matters. People are the end-users of the urban planning process and hence their point of view matters and needs to be integrated into the urban plans. But for the interpretation of large data, their dimensionality should be reduced such that most of the information of the data is restored. The Principal component analysis (PCA) is one of the oldest and widely used methods. [8] [9] . The research question was how to describe Regenerative cities with reduced number of features or characteristics. In the work on Regenerative cities in consideration, a total of 31 variables were derived from the study of

literature on Regenerative cities. 46 students, who had undergone the elective course on Urban Design and Regeneration, responded to the questionnaire prepared by the researcher. The assumption was that variables with common traits group together into a more general character. Thus the reduced number of characteristics will make possible efficient integration into the masterplan for urban planners and designers. To work with the large database for construction of the factor model, the principal component analysis was applied for reduction in the dimensions of the sample and analysis of the result. The work included: 1. Derivation of variables of Regenerative cities. 2. People participation. 3. Application of the principal component method for dimensionality reduction. 4. Factor dimensions derivation. 5. Construction of the eight-factor model of Regeneration Cities.

Table 1: Methodology
(Source: Author's Work)
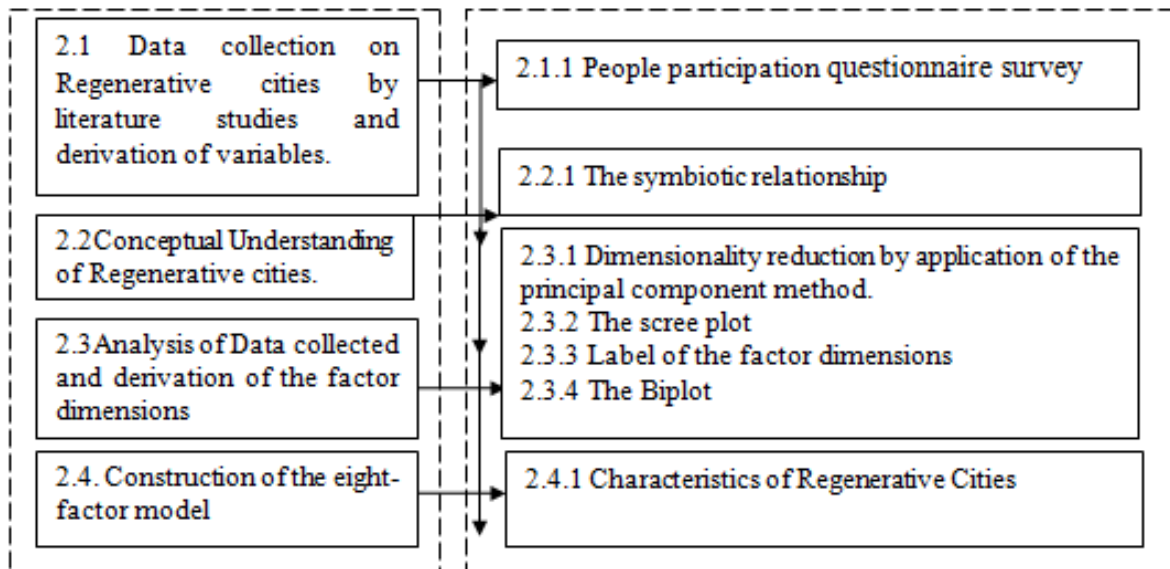
1. **Data Collection on Regenerative Cities by Literature Studies and Derivation of Variables**

Table 2: List of Regenerative Cities Variables

Variables with the literature references	Extraction/ Communalities for the 8 factor matrix
A Enhance and restore natural systems on which the cities depend [10]	0.702
B vegetable and milk production are located closest to the cities in nearby villages[11]	0.817
C Rejuvenating health of earth, human beings and all species [12]	0.725
D solar and wind energy supplied from its hinterland (villages), and on roof tops within the city. [13]	0.682
E circular zero-waste metabolism: every waste output by an organism is also a valuable input which replenishes and sustains the whole living environment. [14]	0.792

F Cities should convert organic waste into compost, and to return plant nutrients and carbon to farmland that feeds cities, to assure its long-term fertility. Green Savings: reducing waste, recycling materials and cutting costs. [15]	0.668
G Efficient ways of supplying food for our cities which includes a new emphasis on local food production. [16]	0.760
H pedestrian zones and cycle lanes, encouragement of public transport and new electric and fuel cell vehicle technology. car sharing as a key feature or urban transport [17]	0.721
I. tree planting for biodiversity and soil erosion control in and around the city. Make carbon sinks (sequestration) a key aspect of tree planting initiatives. Develop initiatives to help restore forests and wetlands in remote areas. [18] [6]	0.849
J Boost the creation of green business by effective use of government procurement. Encourage resource efficiency in all businesses. Create 'green business incubators' across the city. Green Economy: new businesses and jobs by environmental protection and restoration.[6]	0.750
K Ensure that all citizens take a stake in restorative development. Ensure that it is addressed in the education system, and through meetings and events.	0.596
L Green Talent: investing in technical, entrepreneurial and workforce skills [6]	0.808
M cities to minimize their systemic dependence on fossil fuels and their unsustainable use of natural resources. A rapid switch towards powering our cities with renewable energy is a crucially important starting point.	0.628
N Soil enrichment and ground water recharge techniques.	0.793
O Infiltration pits as mandate for recharging of ground water. Increase in unpaved surface.	0.802
P Lake conservation and efficient management as source of water supply	0.784
Q Citizens' participation and democracy [19]	0.721
R Regenerative Vision, leadership and long term target setting [20]	0.770
S Ecologically inspired design of agricultural, and traditional occupational practices to develop capacity building of village communities [21]	0.753
T Self sustenance of villages, hence facilitating intensification and compactness of cities	0.856
U City that offers people increased opportunities for learning, work and living [22]	0.745
V A regenerative city produces more energy than it consumes	0.785
W A regenerative city preserves and redefines and revives its historical features and heritage buildings [22]	0.714
X A regenerative city has efficient global communication but local ways of finding contextual solutions	0.625
Y A regenerative city is governed by urban policies that support integrated regenerative urban planning as a key organizing principle [23]	0.756

Z Modify building codes to make resource efficient building practice the norm [23]	0.789
AA Preserves agricultural land and retrofitting cities for urban farming [24]	0.831
AB Circular metabolism city with local cycle of materials, water, food, energy, manufactured goods, bio based materials from reuse. [25]	0.824
AC Community regeneration by strengthening the involvement of local individuals and communities in decision making, [26]	0.764
AD Integration of natural and manmade systems in development of regenerative cities. [3]	0.771
AE Priority is given to closing the urban resource cycle which means finding value in outputs that are conventionally regarded as waste and using them as resource input in local and regional production systems. [27]	0.690

People Participation Questionnaire Survey: The people participation questionnaire survey was carried out on 46 students of sixth semester from various streams of engineering, who had undergone the course on Urban Design and Regeneration. These students made a brief literature study on Regenerative Cities. They were also given a talk on Regenerative Cities by the researcher. The variables were evaluated on a scale that ranged from 0 to 10. A high score of a particular variable meant that it aligned very well to the concept of Regenerative cities, whereas a low score meant that it did not align well. Google forms were used for this purpose.

2. Conceptual Understanding of Regenerative Cities

The Symbiotic Relationship: The symbiotic relationship with nature is the substratum on which the regenerative city thrives. Hence each of the characteristic of the regenerative city model has two parts. One is the gross, ever undergoing changes and the other is a relatively subtle slow changing entity. Both of which are intertwined, inseparable and seem to be one entity even though they inherently work as two separate entities. This seeming contradiction and the role of the entities need to be recognized and responded to. For instance, the green transportation entity is more gross, consisting of physical components that are mobility based, noisy, full of activities and subject to rapid changes over time, whereas the natural system, the very base on which transportation system operates, into which it is ingrained is relatively quiet, immovable, made of subtle activities that are subject to very slow changes over time. Buses moving on the roads are an everyday noisy changing phenomenon, whereas formation of rocks, rains or the growing of trees is a relatively very slow quiet subtle natural phenomenon. The transportation system ceases to survive, if it works as an independent entity, without the recognition of the substratum of the natural system, and without alignment to the natural laws. This partnership of restorative relationship should be the key organizing principle for urban operations. The methodology adopted was based on people participation that seeks to define the ways of thinking as well as the context based tangible actions.

Ways of thinking and tangible actions are inherently linked to each other. The ways of thinking or the attitude of the urban systems hence become crucial as they

directly have an impact on the natural system with which they are intertwined. Nature can no longer be considered as a provider of resources, as it can only be so, when the urban system returns the resources it has received. Urban systems cannot survive without the natural systems, but the reverse of the statement is not true. Natural systems have always been there and will continue to exist forever. History is the evidence to show that urban systems have become extinct and reborn. They come and go. Hence urban systems are responsible for giving back materials efficiently to the natural system, to receive resources from nature and restore the regenerative cycle for its own survival.

## 3. Analysis of Data collected and Derivation of the Factor Dimensions

- **Dimensionality Reduction by Principal Component Analysis**

Table 3: Total Variance explained by the 8-Factor Matrix

Initial Eigenvalues:								
	F1	F2	F3	F4	F5	F6	F7	F8
Total	12.437	2.223	1.943	1.628	1.532	1.325	1.172	1.012
Variability (%)	40.119	7.170	6.268	5.250	4.942	4.275	3.780	3.265
Cumulative %	40.119	47.289	53.557	58.808	63.750	68.024	71.805	75.069
The extracted sum of squared loadings								
	F1	F2	F3	F4	F5	F6	F7	F8
Total	12.437	2.223	1.943	1.628	1.532	1.325	1.172	1.012
Variability (%)	40.119	7.170	6.268	5.250	4.942	4.275	3.780	3.265
Cumulative %	40.119	47.289	53.557	58.808	63.750	68.024	71.805	75.069
The rotated sum of squared loadings								
	F1	F2	F3	F4	F5	F6	F7	F8
Total	9.945	9.438	8.267	5.584	3.164	1.753	4.838	6.927
Variability (%)	14.483	13.830	12.049	7.904	5.766	4.888	6.745	9.404
Cumulative %	14.483	28.313	40.362	48.266	54.032	58.920	65.665	75.069

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft Excel 16.015225

- **The Scree Plot**
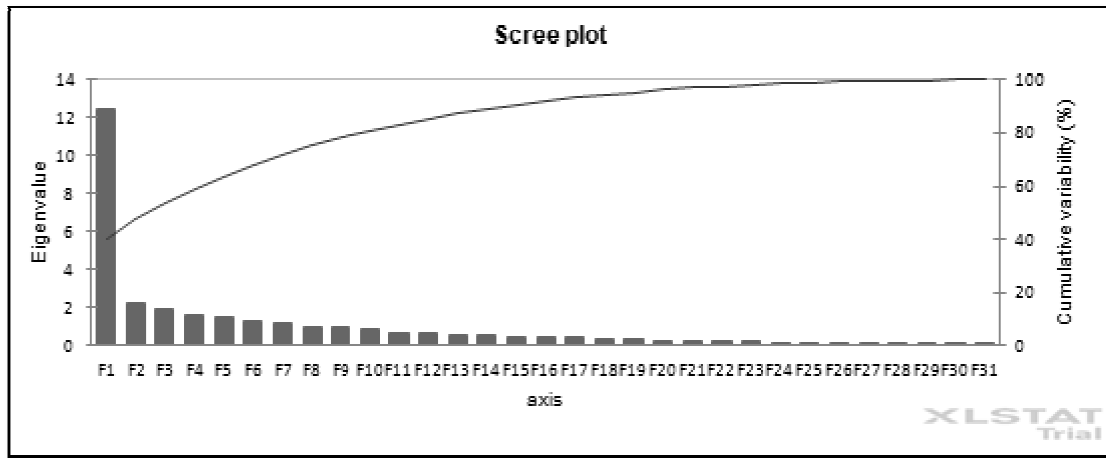
Graph 1: The Scree Plot

Table 4: Principal Component Analysis

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
Eigenvalue	12.437	2.223	1.943	1.628	1.532	1.325	1.172	1.012	0.982	0.844
Variability (%)	40.119	7.170	6.268	5.250	4.942	4.275	3.780	3.265	3.168	2.723
Cumulative %	40.119	47.289	53.557	58.808	63.750	68.024	71.805	75.069	78.237	80.959

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8 Microsoft

- **Label of the Factor Dimensions**

Factor Dimension 1

Table 6: Factor Dimension 1 (source: Research survey data Author work)

Factor D1 **Variables**	**Factor Loadings**	**Communality %**
S. Ecologically inspired design of agricultural, and traditional occupational practices to develop capacity building of village communities	0.593	75.3%
J. Boost the creation of green business by effective use of government procurement. Encourage resource efficiency in all businesses. Create 'green business incubators' across the city. Green Economy: new businesses and jobs by environmental protection and restoration.	0.590	75.0%

P. Lake conservation and efficient management as source of water supply	0.395	78.4%
I. tree planting for biodiversity and soil erosion control in and around the city. Make carbon sinks (sequestration) a key aspect of tree planting initiatives. Develop initiatives to help restore forests and wetlands in remote areas.	0.371	84.9%
H. pedestrian zones and cycle lanes, encouragement of public transport and new electric and fuel cell vehicle technology. car sharing as a key feature or urban transport	0.304	72.1%
variability		14.483
Cumulative %		14.483%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of five out of 31 variables were loaded on the factor. Out of 75.069% of communality, this factor represents 14.483%.

Label: Green transportation and green economy responsive to the natural systems

Factor Dimension 2

Table 7: Factor Dimension 2 (Source: Research Survey Data Author Work)

Factor D2 Variables	Factor Loadings	Communality %
AA Preserves agricultural land and retrofitting cities for urban farming	0.608	83.1%
AC Community regeneration by strengthening the involvement of local individuals and communities in decision making,	0.575	76.4%
AD Integration of natural and manmade systems in development of regenerative cities.	0.483	77.1%
AB Circular metabolism city with local cycle of materials, water, food, energy, manufactured goods, bio-based materials from reuse.	0.339	82.4%
K Ensure that all citizens take a stake in restorative development. Ensure that it is addressed in the education system, and through meetings and events.	0.330	59.6%
C Rejuvenating health of earth, human beings and all species	0.214	72.5%
AE Priority is given to closing the urban resource cycle which means finding value in outputs that are conventionally regarded as waste and using them as resource input in local and regional production systems.	0.197	69%
variability		7.170
Cumulative %		47.289%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of seven out of 31 variables were loaded on the factor. Out of 75.069% of communality, this factor represents 7.170%.
Label: social infrastructure integrated with natural systems

Factor Dimension 3

Table 8: Factor Dimension 3 (Source: Research Survey Data Author Work)

Factor D3 Variables	Factor Loadings	Communality %
E circular zero-waste metabolism: every waste output by an organism is also a valuable input which replenishes and sustains the whole living environment.	0.634	79.2%
Y A regenerative city is governed by urban policies that support integrated regenerative urban planning as a key organizing principle	0.544	75.6%
Z Modify building codes to make resource efficient building practice the norm	0.414	78.9%
R Regenerative Vision, leadership and long term target setting	0.324	77.0%
F Cities should convert organic waste into compost, and to return plant nutrients and carbon to farmland that feeds cities, to assure its long-term fertility. Green Savings: reducing waste, recycling materials and cutting costs.	0.234	66.8%
Q Citizens' participation and democracy	0.195	72.1%
variability		6.268
Cumulative %		53.557%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of six out of 31 variables were loaded on the factor. Out of 75.069% of communality, this factor represents 6.628%.
Label: Community Participation, visionary leadership and urban policies supportive of circular zero waste metabolism.

Factor Dimension 4

Table 9: Factor Dimension 4 (Source: Research Survey Data Author Work)

Factor D4 Variables	Factor Loadings	Communality %
L Green Talent: investing in technical, entrepreneurial and workforce skills	0.687	80.8%

T Self sustenance of villages, hence facilitating intensification and compactness of cities	0.388	85.6%
U City that offers people increased opportunities for learning, work and living	0.377	74.5%
variability		5.250
Cumulative %		58.808%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of three out of 31 variables were found loaded on the factor. Out of 75.069% of communality, this factor represents 5.250%.

Label: Eentrepreneurial and workforce skills supportive of compact cities and self sustenance of villages

Factor Dimension 5

Table 10: Factor Dimension 5 (Source: Research Survey Data Author Work)

Factor D5 Variables	Factor Loadings	Communality %
A Enhance and restore natural systems on which the cities depend	0.542	70.2%
G efficient ways of supplying food for our cities which includes a new emphasis on local food production.	0.358	76.0%
variability		4.942
Cumulative %		63.750%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of two out of 31 variables were loaded on this factor. Out of 75.069% of communality, this factor represents 4.942%.

Label: Emphasis on Local food with restorative relationship with nature

Factor Dimension 6

Table 11: Factor Dimension 6 (Source: Research Survey Data Author Work)

Factor D6 Variables	Factor Loadings	Communality %
B vegetable and milk production are located closest to the cities in nearby villages	0.746	81.7%
variability		4.275
Cumulative %		68.024%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

One out of 31 variables were loaded on this factor. Out of 75.069% of communality, this factor represents 4.275%.
Label: Daily consumables like Vegetable and milk supply to city from hinterland

Factor Dimension 7

Table 12: Factor Dimension 7 (Source: Research Survey Data Author Work)

Factor D7 Variables	Factor Loadings	Communality %
V A regenerative city produces more energy than it consumes	0.687	78.5%
W A regenerative city preserves and redefines and revives its historical features and heritage buildings	0.388	71.4%
X A regenerative city has efficient global communication but local ways of finding contextual solutions	0.377	62.5%
variability		3.780
Cumulative %		71.805%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

A total of three out of 31 variables were loaded on this factor. Out of 75.069% of communality, this factor represents 3.780%.
Label: Emphasis on local heritage in the global communicative context, with regenerative energy

Factor Dimension 8

**Table 13: Factor Dimension 8 (Source: Research Survey Data Author Work)**

Factor D8 Variables	Factor Loadings	Communality %
M cities to minimize their systemic dependence on fossil fuels and their unsustainable use of natural resources. A rapid switch towards powering our cities with renewable energy is a crucially important starting point.	0.511	0.628%
D solar and wind energy supplied from its hinterland (villages), and on roof tops within the city.	0.414	68.2%
N Soil enrichment and ground water recharge techniques.	0.284	79.3%
O Infiltration pits as mandate for recharging of ground water. Increase in unpaved surface.	0.269	80.2%
variability		3.265
Cumulative %		75.069%

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Microsoft

One out of 31 variables were loaded on this factor. Out of 75.069% of communality, this factor represents 3.265%.
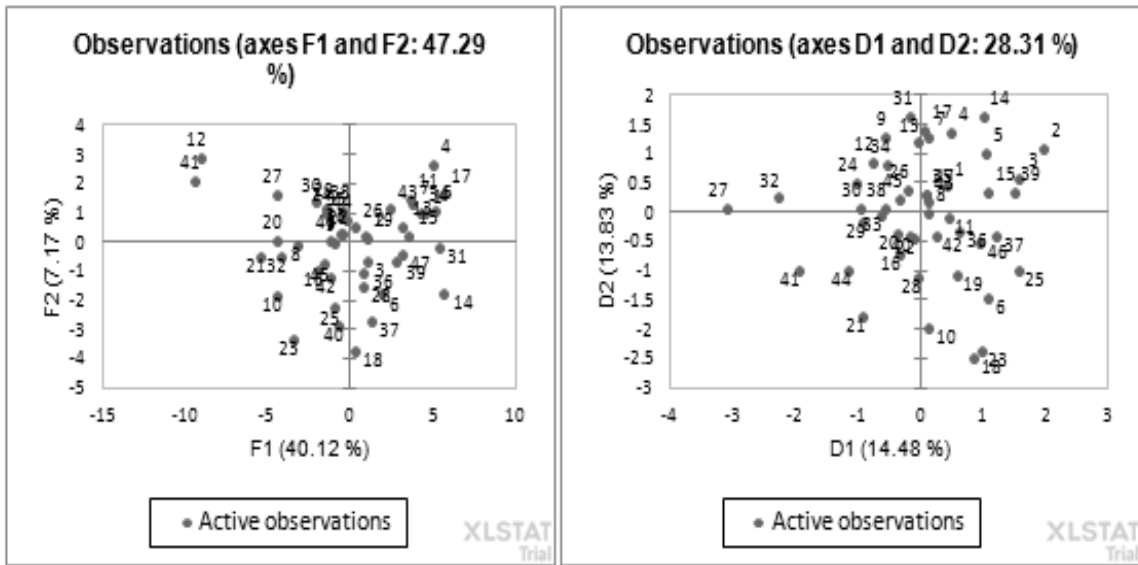Label: Sources of renewable energies aligned for city sustenance

- **The Biplot**
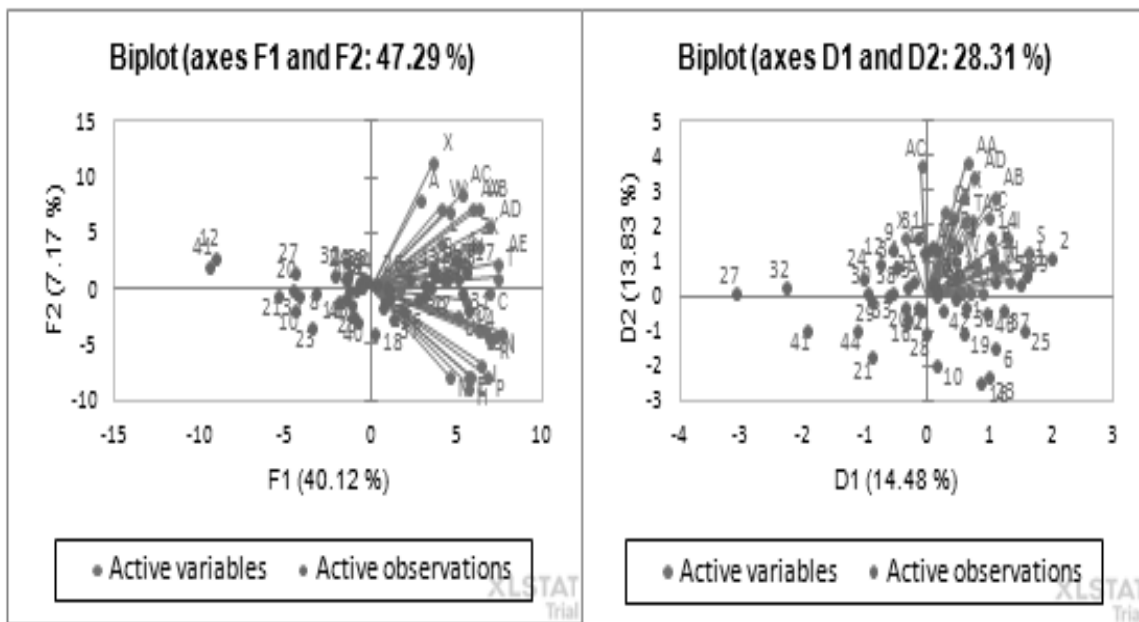
Graph 2: The Biplot Before and After Rotation (Source: Analysis of Data, Author Work)

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Mic

Graph 3: The Observations Before and After Rotation (Source: Analysis of Data, Author Work)

XLSTAT 2021.1.1.1089 - Principal Component Analysis (PCA) PCA type: Correlation Filter factors Maximum number = 8 Standardization: (n) Rotation: Varimax (Kaiser normalization) / Number of factors = 8Mic

All variables have positive values on the Principal Component- 1 (PC1) axis. In the Principal Component - 2 (PC2) axis almost half the number of variables seem to be is negative. Since all variables are positive in PC1, the ones that restrain the system in PC2 lie in the opposite quadrant. The Blue dots are Principal component scores, each dot representing one observation. The orange lines correspond to eigenvectors; data was standardized; the first two PCs account for 47.29% of the total variance of the original dataset. In the PC2 axis, the two sets of variables have opposite effects on the system. All variables seem to be, positively correlated between each other and contributing almost similarly to PC1/PC2. The observation scores are not so well clustered; thus, they all respond to the system not quite uniformly. There were a few outliers too.

4. Construction of the Eight-factor model of Regenerative Cities

The eight characteristic features of the Regenerative city model:

- Green transportation and green economy responsive to the natural systems in the region.
- Social infrastructure including health and education integrated with natural systems
- Community Participation, visionary leadership and urban policies supportive of circular zero waste metabolism.
- entrepreneurial and workforce skills supportive of compact cities and self sustenance of villages
- Emphasis on Local food with restorative relationship with nature
- Daily consumables like Vegetable and milk supply to city from hinterland

- Emphasis on local heritage in the global communicative context, with regenerative energy
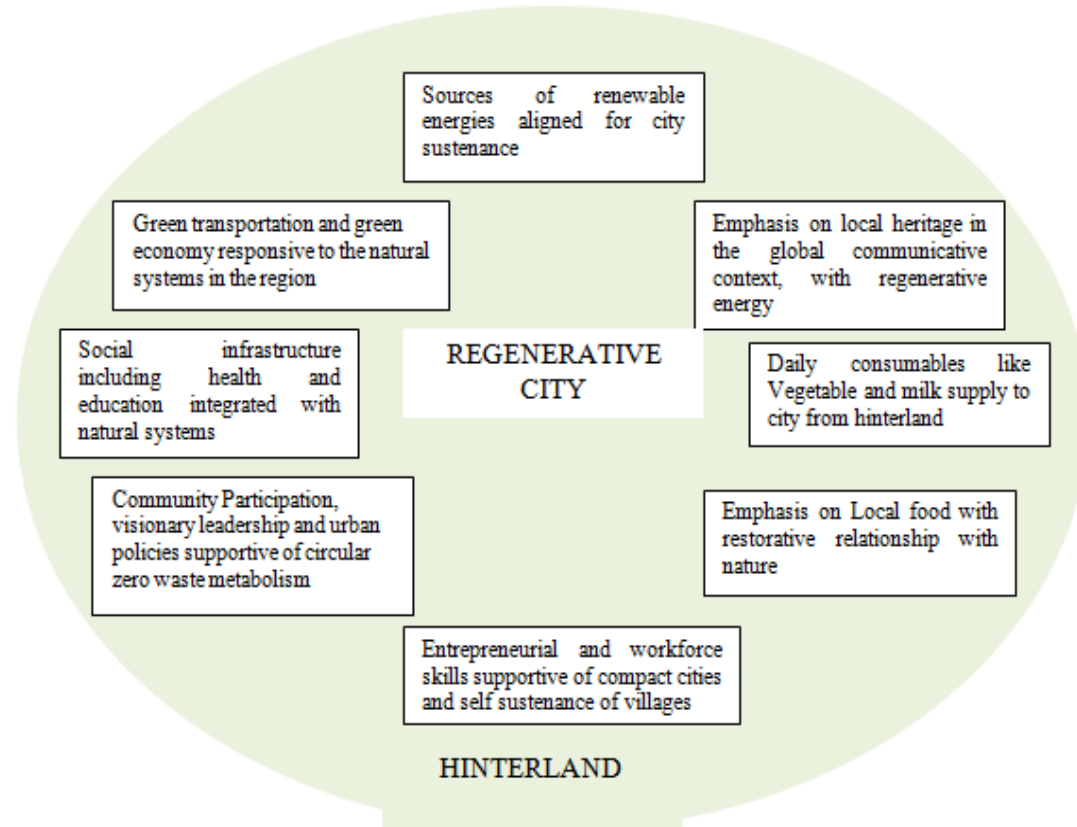- Sources of renewable energies aligned for city sustenance

Figure 1: The Eight Factor Model of Regenerative Cities

III. DISCUSSIONS AND CONCLUSIONS

Importance to the village communities has been given the highest priority in Regenerative cities. There is recognition of the symbiotic relationship that the city has with the villages in the hinterland and the inevitability of capacity building of village communities. Agriculture and traditional occupational practices develop capacity building of village communities. All other features are in support of the enhancement of this relationship.

There is encouragement of resource efficiency in all businesses in the creation of 'green business incubators' across the city, along with new businesses and jobs to be created by environmental protection and restoration. There is encouragement of pedestrian zones and cycle lanes, public transport and new electric and fuel cell vehicle technology. Car sharing is a key feature of urban transport as it creates opportunity intermodal connections. Slow and innovative mobility as a key feature of the city transportation system, in support with the natural systems has been seen as a possibility for the efficient development of regenerative cities.

In addition to the integration of the economy and transportation with environment protection and regeneration, there is enhancement of natural systems like lakes for urban

infrastructure support, along with tree planting for soil erosion control in the enrichment of the biodiversity. The importance of regeneration of biodiversity as the very substratum on which the urban systems to operate. This fact is focussed upon and is a characteristic feature of Regenerative cities.

The possibility of agricultural practices in cities as a unique concept will go a long way in enhancing well being of the city residents. This variable has therefore been highlighted. The fact that there can be no survival and continuation of the man made developments unless they have to be efficiently integrated into the natural laws of the environment is demonstrated in regenerative cities. The concept that cities function as living organisms that inhale and exhale, excrete, consume, undergo metabolism is recognized.

The social aspect of people participation and involvement is crucial as meaningful input for regenerative development. The process of participation invites local people to play an important role in the research process, while also providing a range of data that will support in the planning process to meet local requirements and make regeneration possible. The well being of one is in the well being of all, as the nature, man and all species are intimately connected and depend on one another for survival. This fact forms the basis of regenerative cities.

Regenerative cities seek to follow the circular metabolic systems found in the natural system where in new growth is continuously fed by the organic nutrients of waste. They transform themselves from continuous extraction of resources from hinterland into self-regulating systems socially, economically, as well as environmentally viable. This is crucial to the future well-being of the humanity.

Regenerative cities enhance natural habitats for improvement in soil quality and land restoration.

Regenerative cities are governed by energy performance standards, implement capacity building programs, develop technical documents and create awareness to enhance professional skills and enforce building codes for energy conservation.

Regenerative cities maintain and enhance traditional food and processes, by orientation to health and well being rather than economic models of productivity.

Regenerative cities will invest in ecological infrastructure and the restoration of rivers and lakes in urban areas. It finds such environmentally and socially desirable, approaches economically sound and of benefit to the society.

In regenerative cities the quantity of dairy farming and degree of market participation increases as the city markets and local centers are in close proximity. Dairy farms in the hinterland are well connected to local markets and milk collection centers.

Regenerative cities by its redefinition to environmental and human health, strives for physical, mental and social well-being of all species on earth.

Regenerative cities adopt composting practices to treat organic wastes to ensure long term fertility of its farms and fields.

Regenerative cities deploy renewable energy to ensure energy security. It provides access to affordable, reliable, regenerative energy for citizens. The government policies and programs increasingly support renewable energy markets and foreign investments. It will create jobs locally.

The energy and material flows of a city described as urban metabolism describes the regenerative city as an organism and emphasize on the material flows of the whole living environment.

We have attempted to propose a factor model that addresses the dynamism of the symbiotic relationship of the urban with the natural environment and one that aligns the human goals with the larger economic, social and environment systems. The methodology adopted was based on people participation that seeks to define the ways of thinking as well as the context based tangible actions. Factor analysis was the statistical technique used based on the principal component analysis method using the software XLSTAT 2021.1.1.1089 The results of the analysis indicated that the first two principal components accounted for 47.29% of the total variance of the original dataset. Almost all variables were positively correlated to each other and contributed well to principal components PC1 &PC2. The observations were well clustered; but for a few outliers. An eight-factor model of Regenerative cities was constructed and the factor dimensions labelled. The characteristics of Regenerative Cities was discussed. The limitation of the work was that people participation was represented by students as they were well versed with the subject matter. The variables derived by the researcher, although based on literature studies, may have some limitations. These issues may have affected the results obtained. Overcoming these limitations in further work can bring out more accurate analysis and results.

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