

Measuring progress toward urban sustainable development using a quantitative model (Case study: Cities in Iran)

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Abstract: Sustainable development offers a new concept for the world economy in the twenty-first century. Rather than focusing solely on income, sustainable development encourages cities, countries, and the world to focus simultaneously on three goals: economic prosperity, social inclusion, and environmental sustainability. Cities will be in the front lines of the battle for sustainable development. Not only do they face direct threats; they also have the best opportunities to identify and deliver solutions. As high-density, high-productivity settlements, cities can provide greater access to services of all kinds—including energy, water, health, education, finance, media, transport, recycling, and research – than can most rural areas. In this study first, ten indicators of Sustainable Development, some with positive relationship with sustainable development and some with negative relationship were chosen and information related to performances of 8 indices of 28 cities of Iran's country in years 1995, 2000, 2005 and 2010 extracted. After extracting indices and processing them, indices were standardized. In the next step and after standardizing, using McGranahan method, correlation matrix of indices was calculated by SPSS software and weight of each index was determined. After this step, weight of each index was multiplied on each standardized index and at the end composite index for each city was calculated for 1995, 2000, 2005 and 2010. Then, these composite indexes were sorted by descending. Stability numbers obtained using this method for Tehran for these years are 364, 369, 347 and 344 respectively, which was always higher than the average of 28 cities. Tehran's rank was always between 4 and 9 showing undesirable performance which requires suitable actions.

Keywords: Sustainable Development, Quantitative, Progress, McGranahan Method, Indicator

1. Introduction

With the growth of knowledge and technology and the beginning of agriculture and domesticating the animals, human supply his needs which usually is connected with the environment. The human has made some changing on the ecosystem of the earth in comparison with the other animals. And With the growth of industry and blooming of it the same as industrial revolution, many changing has been done by the human in the ecosystem. However, in many parts of the world the ecosystem has been destroyed by the human. In recent researches, the connections of earth capacity for supporting humans with the economic,

environment, culture and population were found which were completely limited [1]. So some opinions and actions for correcting the relation between human and environment has been done, that it caused the forming of sustainable development.

In 1987, world's commission to environment and development was introduced. This report by the name of "our common future" presented some states and original rules for arriving sustainable development for developing countries. The version of sustainable development for the first time as usual was stated in this report [2]. And in the Rio international conference was approved [3]. The most acceptable define from sustainable development, is define that was stated in Brantland report. Depend on this report;

the growth of sustainable development depends on human needs and without making any damage to needs of new generation [4]. Meaning the sustainable development is a long time model development [5], in the position of sustainable development it consists on preventing from damage to the environment, destroying the ecosystem preventing from agnostic, pollution, high population, and decreasing the quality of living for humans in reality the complete sustainable conditions is prepared when a total sustainable of environmental with equal aim of ecological, sustainable in economy, social sustainable with the aim of social justice and sustainable frame for sustainable aim of morphological be fixed [6].

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [7]. The primary objective of sustainable development is to reduce the absolute poverty of the world's poor through providing lasting and secure livelihoods that minimize resource depletion, environmental degradation, cultural disruption and social instability.

The Earth Summit (UNCED), which took place in Rio de Janeiro in 1992, recognized the pressing environment and development problems of the world and, through the adoption of Agenda 21, produced a global programme of action for sustainable development in the 21st century. Agenda 21 stresses the importance of partnerships in improving social, economic and environmental quality in urban areas. It suggests renewed focus on effective land use planning to include adequate environmental infrastructure, water, sanitation, drainage, transportation and solid waste management, in addition to a sound social infrastructure capable of alleviating hunger. According to Afonja (1999), the Earth Summit broadened environmental issues and emphasized the synergies with other social and economic policy issues [8].

The 1997 Special Session of the UN General Assembly set a target date of 2002, for the formulation and elaboration of national strategies for sustainable development. National governments are to integrate environmental, economic and social objectives into decision-making by either elaborating new policies or strategies for sustainable development, or by adapting existing policies and plans. It also reaffirmed that all sectors of the society should be involved in their development and implementation. The World Summit for Sustainable Development (WSSD), held in August 2002, urged in its Plan of Implementation that nations should take steps to make progress in the formulation and elaboration of national strategies for sustainable development and begin their implementation [9].

Sustainable development offers a new concept for the world economy in the twenty-first century. Rather than focusing solely on income, sustainable development encourages cities, countries, and the world to focus simultaneously on three goals: economic prosperity, social inclusion, and environmental sustainability [10].

In the other word, sustainable development is joining of bio ecosystem and social with economic subjects (Bio environment and society). Such developing is against with unsustainable growth economic and states this reality that, the kind of living is equal with some hazards [11]. If we consider the three elements of sustainable developing (social, economy and environment) the results would be more accurate as it has been shown. Nevertheless (Figure 1) stating so developments, that it is not very good, because the ingredients of sustainable development are not in equal with each other [12].

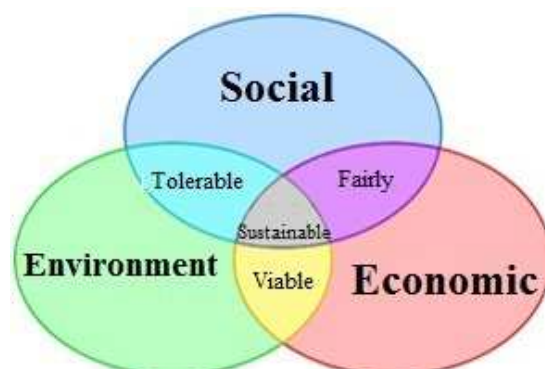


Figure 1. Stability of undesirable(Enayati,2009)

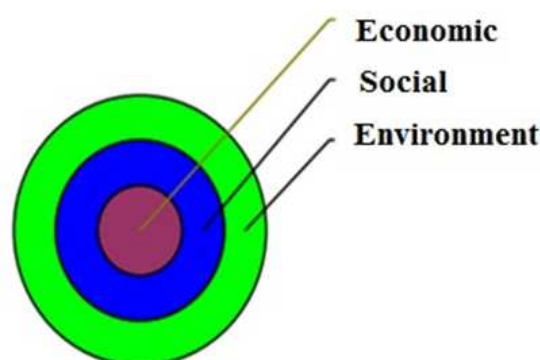


Figure 2. Optimal stability (Enayati, 2009)

The most serious problems confronting cities, towns and their inhabitants as identified in Agenda 21 (1996) include the following: Inadequate financial resources, lack of employment opportunities, spreading homelessness and expansion of squatter settlements, increased poverty and a widening gap between the rich and poor, growing insecurity and rising crime rates, inadequate and deteriorating building stock, services and infrastructure. Other problems include lack of health and educational facilities, improper land use, insecure land tenure, rising traffic congestion, increasing pollution, lack of green spaces, inadequate water supply and sanitation, uncoordinated urban development and an increasing vulnerability to disaster. All these have seriously challenged the capacity of government at all levels to realize socio-economic development and environmental protection, which are all components of sustainable development [13].

Cities will be in the front lines of the battle for

sustainable development. Not only do they face direct threats; they also have the best opportunities to identify and deliver solutions. As high-density, high-productivity settlements, cities can provide greater access to services of all kinds – including energy, water, health, education, finance, media, transport, recycling, and research – than can most rural areas [14].

Urban development is especially important within the broader context of sustainability. The reality of "accelerated urbanization growth in the south countries (like Iran) overrides its damaging influence in local and global scales; "e.g. environmental, social, economical and political problems such as an increase in resource demands, waste production, air pollution, poverty, inequity, housing shortages, crimes, narcotic use... caused concerns about urban sustainable development.

The need for sustainable urban planning and development reached an important point in 2007, when half of the world's population was defined as living in cities [15]. Therefore the aim of this research is measuring progress toward Urban Sustainable Development in Iran.

2. Materials and Methods

In order to prepare compiled indexes, first we extracted and classified urban sustainable development indexes for a number of cities from sustainable development index database of United Nations. Since the indicators used in sustainable development are not in the same scale and some are in percent and some in tons, thus adding these indicators with different scales to achieve a combined index is not possible. Therefore it is essential to convert these indices to standard units so it is possible to collect them. Although the methods for achieving standard scales, which is called normalization, are not without problems, but they are ways used for achieving combined indices. In this research, for normalization we used "Division by Mean" method. In this method, after extraction of selected indicators and cities, values of each indicator was divided by the mean of all indicators in the column, resulting a new indicator without scale. To implement this method, the following formula is used [16]:

$$Y = X_{ij} / \bar{X}$$

Y = the amount fixed by the scale

X_{ij} = value of index in city j

\bar{X} = mean of each index in every column

After normalization of each column, it is necessary to calculate appropriate weight of each indicator. In this study, we used McGranahan method (1970) for weighting which calculated using SPSS package. After calculation of weight of each indicator, it was multiplied by previously calculated scale-less indices. Then, calculated values in each row were added to get combined indicator (sustainability number) for each city. Combined indicators are sorted in descending order based on which we can determine the ranking of selected cities [17].

2.1. Urban Sustainable Development Indexes

In 2010 the government published its strategy for main streaming sustainability and in it gave an undertaking to publish a revised set of Sustainable Development Indicators (SDIs).

The SDI set consisted of 68 indicators comprising 126 measures. This set is formed of fewer indicators: 12 headline and 23 supplementary indicators, comprising 25 and 41 measures respectively. The reduced size of the set follows the example of other international institutions in identifying a core set of headline indicators to highlight sustainable development priorities for users and government. It was also in part prompted by the need for alignment with the Office for National Statistics' development of national wellbeing measures, which are closely related to measures of sustainable development. Where appropriate the measures used in the indicator set also aligns with other indicator frameworks, such as those which measure progress against government departments' business plans and the Public Health Outcomes Framework.

The indicators provide an overview of national progress towards a more sustainable economy, society and environment. The SDIs are used as a means of assessing whether the nation as a whole is developing sustainably, and as a means for policy-makers to identify more sustainable policy options. They are not used to evaluate individual policies due to their high-level nature.

The SDIs are designated National Statistics by the Iran's Statistics Authority. Assessments of compendium publications against the Code of Practice for Official Statistics relate to the processes involved in preparing the publication and its presentation. This can broadly be interpreted as meaning that the statistics meet identified user needs, are well explained and readily accessible, are produced according to sound methods and are managed impartially and objectively in the public interest.

2.2. Statistical Analysis and Calculation of Composite Indicators for Urban Sustainable Development, for Selected Cities in Years 1995, 2000, 2005 and 2010

In this study, first, ten indicators of urban sustainable development, some with positive relationship with sustainable development and some with negative relationship were chosen as follows:

- Air Quality
- Economic prosperity
- Land Use
- Poverty
- Waste Disposal and Recycling
- Water Use
- Water Quality
- Healthy Life Expectancy
- Population Demographics
- Energy from Renewable Source

Among the factors mentioned above, the use of some indicators, due to lack of data for many cities and remote

data for some of them, also due to different definitions of the indicators was not possible and for this reason among 10 indicators above, 8 of them were chosen as follows:

- X1: Air Quality (positive relationship with sustainable development)
- X2: Economic prosperity (positive relationship with sustainable development)
- X3: Land Use (positive relationship with sustainable development)
- X4: Poverty (negative relationship with sustainable development)
- X5: Disposal and Recycling (positive relationship with sustainable development)
- X6: Water Use (positive relationship with sustainable development)
- X7: Water Quality (positive relationship with sustainable development)
- X8: Population Demographics (positive relationship with sustainable development)

After selecting indicators, the raw data for each of the indices were collected for 28 cities from different regions of the Iran from Sustainable Development database, in the

four-period 1995, 2000, 2005 and 2010. After extracting the data, the table (Cities in rows and indicators in columns) was prepared. As from eight indicators, one was in negative relationship with sustainable development; first we transform it so that it has positive direction. For this purpose, the values of each of the indicators were deducted from a constant. After this, related indicators for each city standardized by dividing each value by the average to allow comparison. After standardization, the weight of each indicator should be calculated for each of the years studied. In this study, McGranahan method for weighting indicators is used. The McGranahan method assumption is this that the weights should be indicative of importance of an indicator among other indicators which is determined through the correlation of each indicator with others. In other words, in this method the more the correlation of a variable with other variables is, the more it weighted and vice versa. On this basis, to determine the weight of each indicator, correlation matrix was calculated for each of the indicators and the average correlation coefficient, as an indicative of importance of each indicator was calculated (Tables 1, 2, 3 and 4).

Table 1. Correlation matrix of indicators in 1995.

	x1	x2	x3	x4	x5	x6	x7	x8	Mean weight
X ₁	1	0.378	-0.171	0.178	0.145	0.202	0.327	0.193	0.28867
X ₂	0.378	1	-0.144	0.341	0.082	0.142	0.133	0.401	0.29983
X ₃	-0.171	-0.144	1	0.062	-0.025	-0.099	-0.131	0.076	0.10383
X ₄	0.178	0.341	0.062	1	0.029	0.213	0.372	0.081	0.30383
X ₅	0.145	0.082	-0.025	0.029	1	0.702	0.118	0.057	0.32217
X ₆	0.202	0.142	-0.099	0.213	0.702	1	0.221	0.116	0.36000
X ₇	0.115	0.118	0.04	0.008	0.122	0.673	1	0.029	0.325667
X ₈	0.15	0.065	-0.023	0.01	0.081	0.677	0.12	1	0.313167

Table 2. Correlation matrix of indicators in 2000.

	x1	x2	x3	x4	x5	x6	x7	x8	Mean weight
X ₁	1	0.274	0.08	-0.167	0.15	0.128	0.145	0.115	0.244167
X ₂	0.274	1	0.133	-0.322	0.065	0.158	0.082	0.118	0.218
X ₃	0.08	0.133	1	0.056	-0.023	0.098	-0.025	0.04	0.224
X ₄	-0.167	-0.322	0.056	1	0.01	-0.146	0.029	0.008	0.071833
X ₅	0.15	0.065	-0.023	0.01	1	0.677	0.12	0.081	0.313167
X ₆	0.128	0.158	0.098	-0.146	0.677	1	0.702	0.673	0.319167
X ₇	0.084	0.234	-0.076	0.116	0.658	0.677	1	0.202	0.336
X ₈	0.102	0.122	0.086	0.057	0.145	0.658	0.158	1	0.3375

Table 3. Correlation matrix of indicators in 2005.

	x1	x2	x3	x4	x5	x6	x7	x8	Mean weight
X ₁	1	0.327	-0.081	0.197	0.115	0.111	0.333	0.178	0.278167
X ₂	0.327	1	-0.131	0.372	0.118	0.221	0.158	0.341	0.317833
X ₃	-0.081	-0.131	1	0.008	0.04	-0.097	-0.113	0.062	0.123167
X ₄	0.197	0.372	0.008	1	0.008	0.12	0.401	0.133	0.284167
X ₅	0.115	0.118	0.04	0.008	1	0.673	0.122	0.029	0.325667
X ₆	0.111	0.221	-0.097	0.12	0.673	1	0.234	0.213	0.338
X ₇	0.202	0.142	-0.099	0.213	0.702	0.221	1	0.116	0.36000
X ₈	0.178	0.341	0.062	0.081	0.029	0.213	0.372	1	0.30383

Table 4. Correlation matrix of indicators in 2010.

	x1	x2	x3	x4	x5	x6	x7	x8	Mean weight
X ₁	1	0.333	-0.103	0.193	0.102	0.084	0.15	0.158	0.268167
X ₂	0.333	1	-0.113	0.401	0.122	0.234	0.065	0.378	0.3295
X ₃	-0.103	-0.113	1	0.076	0.086	-0.076	-0.023	-0.171	0.145

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	Mean weight
X ₄	0.193	0.401	0.076	1	0.057	0.116	0.01	0.178	0.307167
X ₅	0.102	0.122	0.086	0.057	1	0.658	0.158	0.145	0.3375
X ₆	0.084	0.234	-0.076	0.116	0.658	1	0.677	0.202	0.336
X ₇	0.15	0.065	-0.023	0.01	0.12	0.677	1	0.081	0.313167
X ₈	0.178	0.327	-0.081	0.197	0.115	0.111	0.333	1	0.278167

After an average weight of each index was calculated, obtained numbers was multiplied by standardized indicators. After these steps, sustainability number of each of the cities based on eight indicators in four-period 1995, 2000, 2005 and 2010 was calculated by adding the numbers

in each row. In order to better comparison the final numbers was multiplied by 100 (Tables 5 to 8).

3. Results

Table 5. Rank and sustainable development number 1995.

Rank	City	Sustainability number	Rank	City	Sustainability number
1	Sari	456	15	Yazd	254
2	Mashhad	424	16	Ahvaz	254
3	Tabriz	390	17	Ardabil	252
4	Tehran	364	18	Ghom	251
5	Esfahan	339	19	Zanjan	245
6	Shiraz	339	20	Khoramabad	243
7	Kermanshah	332	21	Sanandaj	241
8	Hamedan	328	22	Arak	239
9	Ghazvin	327	23	Kerman	238
10	Rasht	324	24	Shahrekord	238
11	Bandarabas	321	25	Bushehr	236
12	Orumie	314	26	Yasoj	232
13	Semnan	306	27	Ilam	227
14	Gorgan	303	28	Zahedan	227

Table 6. Rank and sustainable development number 2000.

Rank	City	Sustainability number	Rank	City	Sustainability number
1	Sari	464	15	Yazd	288
2	Mashhad	439	16	Ahvaz	279
3	Tabriz	412	17	Ardabil	272
4	Esfahan	374	18	Ghom	267
5	Tehran	369	19	Arak	261
6	Shiraz	345	20	Zanjan	257
7	Kermanshah	342	21	Sanandaj	253
8	Hamedan	338	22	Khoramabad	251
9	Rasht	334	23	Bushehr	249
10	Ghazvin	331	24	Shahrekord	247
11	Bandarabas	328	25	Kerman	244
12	Gorgan	325	26	Yasoj	239
13	Orumie	317	27	Ilam	236
14	Semnan	312	28	Zahedan	229

Table 7. Rank and sustainable development number 2005.

Rank	City	Sustainability number	Rank	City	Sustainability number
1	Sari	467	15	Yazd	297
2	Mashhad	441	16	Ahvaz	288
3	Tabriz	410	17	Ghom	286
4	Shiraz	357	18	Zanjan	281
5	Esfahan	353	19	Sanandaj	279
6	Kermanshah	348	20	Arak	276
7	Tehran	347	21	Bushehr	269
8	Rasht	342	22	Khoramabad	257
9	Hamedan	337	23	Ardabil	254
10	Ghazvin	335	24	Shahrekord	253
11	Bandarabas	332	25	Kerman	249
12	Gorgan	325	26	Yasoj	244
13	Orumie	310	27	Ilam	238
14	Semnan	308	28	Zahedan	232

Table 8. Rank and sustainable development number 2010.

Rank	City	Sustainability number	Rank	City	Sustainability number
1	Mashhad	459	15	Semnan	302
2	Sari	454	16	Ghom	296
3	Tabriz	414	17	Ahvaz	294
4	Shiraz	374	18	Sanandaj	283
5	Esfahan	362	19	Zanjan	280
6	Kermanshah	357	20	Arak	270
7	Rasht	353	21	Bushehr	266
8	Hamedan	349	22	Khoramabad	259
9	Tehran	344	23	Ardabil	256
10	Ghazvin	331	24	Shahrekord	254
11	Bandarabas	329	25	Kerman	252
12	Gorgan	327	26	Yasoj	249
13	Yazd	306	27	Ilam	241
14	Orumie	304	28	Zahedan	237

Base on analysis of combined indices of 28 cities in 1995, three cities Sari, Mashhad and Tabriz with respective sustainability numbers of 456, 424 and 390 have the highest sustainability numbers and three cities Zahedan, Ilam and Yasoj with respective sustainability numbers of 227, 227 and 232 have lowest sustainability numbers and were at the bottom of the list. Average number of sustainability for these cities was 267. In this list Tehran's rank with sustainable number 364, were 4. That show good performance in this area.

In 2000 the three cities, Sari, Mashhad and Tabriz have also topped the table and sustainability numbers for them respectively were 464, 439 and 412. Zahedan, Ilam and Yasoj, respectively with sustainability numbers 229, 236 and 239 have lowest numbers. Average sustainability number of these cities in 2000 was equivalent to 278. Tehran's rank with sustainable number 369, were 5.

In 2005, still Sari, Mashhad and Tabriz, with sustainability numbers 467, 441 and 410 were at the top of the list and three cities Zahedan, Ilam and Yasoj, respectively with sustainability numbers 232, 238 and 244 were in the bottom of the list. Average sustainability number for the mentioned countries in 2005 was 281. Tehran's rank with sustainable number 347, were 7.

In 2010, Mashhad, Sari and Tabriz, with sustainability numbers 459, 454 and 414 were at the top of the list and three cities Zahedan, Ilam and Yasoj, respectively with sustainability numbers 237, 241 and 249 were in the bottom of the list. Average sustainability number for the mentioned countries in 2010 was 284. Tehran's rank with sustainable number 344, were 9.

According to the results, the average "sustainability indicators" have increase in 2000, 2005 and 2010 (first 267 and then the number is 284) which expresses the fact that steps are taken toward sustainable development indexes by the cities and we hoped to achieve sustainable development in urban area. The objections against this indexes is that some cities are trying to reflect unrealistic information to international authorities to more to benefit from sources which usually provided to them by developed Government. Furthermore, based on composite indicators, some cities gain high stability number and have scored high, while the

available evidence reveals other facts. In this way, and despite the structural problems of calculation of sustainability, using composite indexes, this method can show the performance of the cities in the field of Sustainable development. In fact, the use of composite index to calculate stability indices are considered an appropriate method and the main drawback for these method is mainly on the nature of the sub-indices, therefore, if appropriate sub-indices are selected, using the composite indexes we can better analyze and evaluate the performance of cities and even regions and provide more realistic planning and policies to implement. For example, indicators of utilization and use of water in some arid and dry cities of the country is more important than the indicator of Land Use of the city and therefore it is necessary, these indicators to be considered further and raised as sustainable development for that cities.

4. Conclusion

Environmental protection and maintaining its stability, emphasized on the sustainable Development policy, require the acquisition of new patterns of development and exploitation of environmental and natural resources in which the basic needs of the present generation fulfilled, and also provide mechanisms to allow future generations to take advantage of these blessings. This new approach of development, which placed the maintenance and sustainability of environment along with other components of development in the center of attention, and in the development literature, is known as sustainable development, tries to strike a balance between resources and tolerable capabilities of earth, and human needs and purposes.

In this study we tried to analysis and compare constituent indicators of sustainable development using composite indexes in four-period 1995, 2000, 2005 and 2010. On this basis, for 28 cities which have complete data, combination index was calculated for the four sections mentioned above. Based on these rankings, big and developed cities due to the higher stability number were at the top of the list and the small and developing cities were at the bottom of the list. Therefore, paying attention to environmental policies and

programs and review of past development policies and programs, which typically only have economic growth targets is critical and it is necessary for environmental protection, in the framework of goals the sustainable development, to be supported more in the planning and policies of cities. Establishment of national committee and the provincial Sustainable Development, promote popular participation and strengthening pro-environmental NGO, insert the Sustainable Development Goals in various economic, social and environmental development programs, strengthen systems to collect statistics and information on the Sustainable Development Goals, holding training courses and national conferences, facilitate communication of national organizations with international organizations, review policies and utilization of natural resources and environmental programs, etc. are among actions that cities can do to promote the goals of the Sustainable Development. In response to international and regional challenges related to goals of the Sustainable Development, new letters of agreement for coordination of national policies with international programs should be developed and the principle of shared but differentiated responsibilities, should be followed seriously by the United Nations in a way that the obligations of developed countries for Sustainable Development take more practical aspects and on the other hand, developing countries should also mobilize the resources in a way that these resources can be used best in line with goals of the Sustainable Development. This issue, especially about Sustainable Development, which is a public commodity, and therefore less incentive to invest in by people and cities is more important and need more support than other goals from the governments.

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