
Measuring progress toward environmental sustainability using a quantitative model

Shaho Karami¹, Mohammad rezvani², Farzam Poursaghar Sanghachin³, Hatef Marefat⁴

¹Phd Student in Environmental Education, Payame Noor University, Tehran, IRAN

²Department of Environment and Natural resources, Payame Noor University, Tehran, IRAN

³PhD in Environmental Planning, Faculty of Environment, University Of Tehran, Tehran, IRAN

⁴Msc Student in Environmental Engineering, University of Tehran, Tehran, IRAN

Email address:

Karami.sh@ut.ac.ir(Sh. Karami), M_rezvani@pnu.ac.ir(M. Rezvani), farzam_1344@yahoo.com(F. P. Sanghachin),

Hatef_Marefat@yahoo.com(H. Marefat)

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Abstract: During last tow century and after industrial revolution, especially in last fifty years, the world underwent considerable changes in its economical, social, technological and environmental areas. Crisis of underdevelopment, increasing effect of population on environment, uncontrolled exploitation and destruction of environment, poverty, malnutrition in developing countries, the growth of terrorism and social abnormalities, emerging diseases, a variety of social disorders, the income gap between rich and poor countries, and finally increasing destruction of environment are problems that affect human society, both developed and developing ones. Sure, continuity of this situation can face international community with a serious crisis which its miss effects will affect both developed and developing countries. Therefore, confronting these challenges require collaboration of all world countries. Thus, U.N. Millennium manifesto, in terms of millennium development goals in 2000, provided by U.N and approved by majority of world countries, Seventh goal of millennium, “Ensure environmental sustainability” was the main cornerstone of millennium development goals and reaching other goals and objectives of millennium development goals needs protecting environment and assuring its sustainability. By approving these goals, designed models and methods for determining actions and activities in terms of quantitative models. In this survey first, eight indicators of seventh MDG goals, some with positive relationship with sustainable development and some with negative relationship were chosen and information related to performances of 6 indices of 65 countries of world in years 1990, 1995, 2000 and 2005 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 country was calculated for 1990, 1995, 2000 and 2005. Then, these composite indexes were sorted by descending. Stability numbers obtained using this method for Iran for these years are 141, 114, 131 and 139 respectively, which was always lower than the average of 65 countries. Iran’s rank was always between 40 and 45 showing undesirable performance which requires suitable actions.

Keywords: Ensure Sustainability of Environment, Composite Indicators, McGranahan Method, SPSS Software, Quantitative Model

1. Introduction

During last tow century and after industrial revolution, especially in last fifty years, the world underwent considerable changes in its economical, social, technological and environmental areas [1][6] [7]. Over last five decades human society has advanced in many areas

and achievements of the international community, especially in closing decades of twentieth century, was so marvelous that was unimaginable for those who have lived in the early twentieth century [1][8][9][11]. Alongside these tremendous advances, the world society has experienced deplorable regressions which are now facing serious barriers to the international community. Crisis of underdevelopment, increasing effect of population on

environment, uncontrolled exploitation and destruction of environment, poverty, malnutrition in developing countries, the growth of terrorism and social abnormalities, emerging diseases, a variety of social disorders, the income gap between rich and poor countries, and finally increasing destruction of environment are problems that affect human society, both developed and developing ones. Sure, continuity of this situation can face international community with a serious crisis which its miss effects will affect both developed and developing countries. Therefore, confronting these challenges require collaboration of all world countries [1] [12] [14]. In other words, mentioned crisis cannot afford by short-term actions and reactive reactions or inconsistent policies, but with continued and targeted actions, due to them a reasonable level of development of international community to bring. thus, address the growing challenges in the third millennium, requires a new approach to development which put the man in focus and see the economic growth not as a goal but as a means and considers opportunities for future generations to live as important as present generations and puts special attention to biological systems in which human and other being life depends on [2] [13] [16].

In past years the international community witnessed several meetings to address problems of economic, social and specially environment, among them are 1972 summit on human environment in Stockholm, Sweden and earth summit in Rio De Janeiro on environment and human development in 1992, however, many issues and problems on the eve of the third millennium still has glaring and therefore international community came to believe that it shouldOn this basis the millennium development goals (MDG) raised and passed in largest heads of state meetings in September 2000 in New York. The objectives of these goals are a series of timed and measurable targets including combating hunger, poverty, disease, illiteracy, environmental degradation and gender inequality and also create a global partnership for development which has been approved by the countries [3] [15] [17].

2. Materials and Methods

In order to prepare compiled indexes, first we extracted and classified millennium goals indexes for a number of countries from millennium goals index database of United Nations. since the indicators used in seventh goal of millennium development goals are not in the same scale and some are in percent (such as access to safe and healthy drinking water) and some in tons (such as per capita consumption of ozone depleting substances or carbon dioxide emissions), 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 countries, 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 [4][10]:

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

Y = the amount fixed by the scale

X_{ij} = value of index in country j

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 country. Combined indicators are sorted in descending order based on which we can determine the ranking of selected countries [1].

2.1. Background and Framework of the Millennium Development Goals

The Millennium Development Goals (MDGs) are eight international development goals that all 193 United Nations member states have agreed to achieve by the year 2015. They include eradicating extreme poverty, reducing child mortality rates, fighting disease epidemics, and developing a global partnership for development. With goals approved, the world leaders again gathered in Mexico City in March 2002 for purpose of financing for millennium development and provide a framework that was a milestone in the global partnership for millennium development based on which developed and developing countries agreed to reduce poverty through joint action. In the same year, UN member countries in the World, attended in Summit on Sustainable Development (WSSD) in Johannesburg, South Africa in which again achieving millennium goals was reiterated. Also based on Monterrey consensus on March 22, 2002 in Mexico, developing countries need to expand mobilize domestic resources to provide finance resources for MDG-based poverty reduction strategies, using government revenues, household contributions and private investment to the greatest extent possible. In many low-income countries, and virtually all underdeveloped countries, domestic resources alone are not sufficient to achieve the Millennium Development Goals. For this reason, in the eighth goal, on developed countries to assist developing countries is emphasized [5].

However, official development assistance in the years after World War II has taken place in developing countries. Official development assistance, which reduced from 51 percent of donor countries' GDP in 1960 to 33 percent in 1970, reached 35 percent in 1980. This amount was 34 percent until 1990 which reduced to 23 percent in

2002. This year, the 7/0% of GDP was endorsed by all countries in the Monterrey Consensus. Parallel to these developments, many countries around the world committed to include the millennium development goals in their short and medium term policies and programs and report progresses annually to the United Nations. Furthermore, to institutionalize the MDGs, many countries established structures such as national committee of millennium development goals and has begun widespread actions in different areas of the Millennium Development Goals, including seventh goal.

2.2. Statistical Analysis and Calculation of Composite Indicators for MDG Goal Seven, for selected Countries in Years 1990, 1995, 2000 and 2005

In the present study, first, eight indicators of seventh MDG goals (Ensure environmental sustainability), some with positive relationship with sustainable development and some with negative relationship were chosen as follows:

- ratio of area of land covered by forest to area of the country
- ratio of area of protected land (for biodiversity conservation) to The total area of the country
- Energy consumption(per kg of oil equivalent) per dollar
- GDP based on "purchasing power parity"(PPP)
- Per capita carbon dioxide emissions and consumption of ozone depleting substances
- Proportion of population using solid fuels
- ratio of urban and rural populations have a stable source of clean water and sanitation
- ratio of urban and rural population have good health of the environment
- ratio of population have adequate housing (in the form of ownership, rental, the purchase of housing, community or secondary tenant)

Among the factors mentioned above, the use of some indicators, due to lack of data for many countries and remote data for some of them, also due to different definitions of the indicators(For example, the ratio of population have adequate housing) was not possible and for this reason among 8 indicators above, 6 of them were chosen as follows:

- X1: ratio of area of land covered by forest to area of the country as a percentage (positive relationship

with sustainable development)

- X2: ratio of area of protected land (for biodiversity conservation) to The total area of the country (positive relationship with sustainable development)
- X3: energy consumption(per kg of oil equivalent) per dollar of GDP on a purchasing power parity(PPP) (negative relationship with sustainable development)
- X4: the tones total carbon dioxide emissions per year(negative relationship with sustainable development)
- X5: ratio of urban and rural population have sustainable sources of clean water and sanitation as a percentage (positive relationship with sustainable development)
- X6:ratio of urban and rural population have good health of the environment (positive relationship with sustainable development)

After selecting indicators, the raw data for each of the indices were collected for 65 countries from different regions of the world from Millennium Development Goals database, in the four-period 1990, 1995, 2000 and 2005. After extracting the data, the table (countries in rows and indicators in columns) was prepared. As from six indicators, two was in negative relationship with sustainable development, first we transform them so that they have positive direction. For this purpose, the values of each of the indicators were deducted from a constant. After this, related indicators for each country 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 1990

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	Mean weight
X ₁	1	0.378	-0.171	0.178	0.145	0.202	0.28867
X ₂	0.378	1	-0.144	0.341	0.082	0.142	0.29983
X ₃	-0.171	-0.144	1	0.062	-0.025	-0.099	0.10383
X ₄	0.178	0.341	0.062	1	0.029	0.213	0.30383
X ₅	0.145	0.082	-0.025	0.029	1	0.702	0.32217
X ₆	0.202	0.142	-0.099	0.213	0.702	1	0.36000

Table 2. Correlation matrix of indicators in 1995

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	Mean weight
X ₁	1	0.274	0.08	-0.167	0.15	0.128	0.244167
X ₂	0.274	1	0.133	-0.322	0.065	0.158	0.218
X ₃	0.08	0.133	1	0.056	-0.023	0.098	0.224
X ₄	-0.167	-0.322	0.056	1	0.01	-0.146	0.071833
X ₅	0.15	0.065	-0.023	0.01	1	0.677	0.313167
X ₆	0.128	0.158	0.098	-0.146	0.677	1	0.319167

Table 3. Correlation matrix of indicators in 2000

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	Mean weight
X ₁	1	0.327	-0.081	0.197	0.115	0.111	0.278167
X ₂	0.327	1	-0.131	0.372	0.118	0.221	0.317833
X ₃	-0.081	-0.131	1	0.008	0.04	-0.097	0.123167
X ₄	0.197	0.372	0.008	1	0.008	0.12	0.284167
X ₅	0.115	0.118	0.04	0.008	1	0.673	0.325667
X ₆	0.111	0.221	-0.097	0.12	0.673	1	0.338

Table 4. Correlation matrix of indicators in 2005

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	Mean weight
X ₁	1	0.333	-0.103	0.193	0.102	0.084	0.268167
X ₂	0.333	1	-0.113	0.401	0.122	0.234	0.3295
X ₃	-0.103	-0.113	1	0.076	0.086	-0.076	0.145
X ₄	0.193	0.401	0.076	1	0.057	0.116	0.307167
X ₅	0.102	0.122	0.086	0.057	1	0.658	0.3375
X ₆	0.084	0.234	-0.076	0.116	0.658	1	0.336

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 countries based on six indicators in four-period 1990, 1995, 2000 and 2005 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).

Table 5. Rank and stability number 1990

Rank	Country	Sustainability number
1	Venezuela	356
2	Germany	324
3	Austria	290
4	Malaysia	264
5	Sweden	239
6	Japan	239
7	Switzerland	232
8	Brazil	228
9	New Zealand	227
10	South Korea	224
11	Czech Republic	221
12	America	214

Rank	Country	Sustainability number
13	Poland	206
14	Thailand	203
15	Russia	199
16	Cuba	199
17	France	197
18	Chile	197
19	Indonesia	196
20	UK	194
21	Spain	188
22	Netherlands	186
23	Canada	186
24	Bulgaria	182
25	Cameron	181
26	Norway	181
27	Georgia	178
28	Italy	178
29	Bulgaria	168
30	Greece	163
31	Mexico	161
32	Philippines	159

Rank	Country	Sustainability number
33	Nigeria	155
34	Jordan	154
35	Armenia	154
36	Argentina	152
37	Romania	151
38	Ukraine	145
39	Saudi Arabia	143
40	Iran	141
41	China	139
42	Algeria	138
43	Turkey	138
44	Lebanon	136
45	Pakistan	132
46	Oman	127
47	United Arab Emirates	127
48	South Africa	123
49	Diameter	121
50	General	121
51	India	120
52	Kyrgyzstan	120
53	Kuwait	120
54	Tunisia	118
55	Turkmenistan	114
56	Kazakhstan	113
57	Morocco	112
58	Uzbekistan	108
59	Libya	108
60	Bahrain	108
61	Syria	108
62	Bangladesh	104
63	Egypt	102
64	Mongolia	99
65	Tajikistan	95

Table 6. Rank and stability number 1995

Rank	Country	Sustainability number
1	Venezuela	317
2	Germany	238
3	Austria	219
4	Malaysia	202
5	Saudi Arabia	191
6	Japan	188
7	Swedish	187
8	Switzerland	186
9	Spain	183
10	Brazil	181
11	Czech Republic	176
12	South Korea	175
13	Poland	174

Rank	Country	Sustainability number
14	New Zealand	172
15	Thailand	162
16	Russia	158
17	Bulgaria	154
18	Cuba	153
19	America	153
20	Chile	152
21	Netherlands	151
22	Indonesia	150
23	UK	150
24	Canada	150
25	Norway	144
26	Italy	144
27	United Arab Emirates	143
28	Georgia	140
29	Cameron	138
30	France	136
31	Bulgaria	135
32	Greece	135
33	Mexico	134
34	Romania	134
35	Jordan	128
36	Philippines	128
37	Armenia	127
38	Argentina	125
39	Bahrain	125
40	Ukraine	119
41	Tajikistan	119
42	Lebanon	116
43	Nigeria	116
44	Iran	114
45	Turkey	112
46	Algeria	111
47	Oman	110
48	China	109
49	General	107
50	Uzbekistan	105
51	Kazakhstan	105
52	Kyrgyzstan	104
53	Diameter	104
54	Kuwait	103
55	Pakistan	102
56	Turkmenistan	102
57	South Africa	100
58	Tunisia	99
59	Mongolia	98
60	India	94
61	Morocco	94
62	Libya	92
63	Syria	92
64	Egypt	90
65	Bangladesh	81

Table 7. Rank and stability number 2000

Rank	Country	Sustainability number
1	Venezuela	364
2	Germany	294
3	Austria	271
4	Malaysia	250
5	Swedish	243
6	Brazil	242
7	Switzerland	242
8	Japan	239
9	South Korea	218
10	Poland	212
11	Saudi Arabia	212
12	New Zealand	211
13	Czech Republic	206
14	Thailand	201
15	America	194
16	France	194
17	Russia	193
18	Spain	190
19	Cuba	185
20	Indonesia	185
21	Canada	182
22	Bulgaria	182
23	Chile	181
24	Cameron	180
25	Italy	180
26	Georgia	178
27	Mexico	178
28	Norway	176
29	UK	175
30	Netherlands	175
31	Greece	166
32	Bulgaria	163
33	Romania	163
34	Philippines	152
35	Argentina	148
36	Armenia	146
37	China	144
38	Jordan	138
39	Lebanon	137
40	Tajikistan	136
41	Turkey	136
42	Bahrain	135
43	Nigeria	134
44	Ukraine	134
45	Iran	131
46	Oman	128

Rank	Country	Sustainability number
47	Algeria	124
48	India	122
49	Kyrgyzstan	122
50	Pakistan	122
51	Tunisia	121
52	Mongolia	121
53	General	121
54	United Arab Emirates	118
55	South Africa	116
56	Egypt	116
57	Morocco	116
58	Diameter	114
59	Kuwait	114
60	Kazakhstan	112
61	Turkmenistan	109
62	Syria	105
63	Libya	103
64	Bangladesh	103
65	Uzbekistan	99

Table 8. Rank and stability number 2005

Rank	Country	Sustainability number
1	Venezuela	358
2	Germany	304
3	Brazil	266
4	Malaysia	251
5	Swedish	250
6	Japan	246
7	Austria	245
8	Switzerland	243
9	South Korea	226
10	New Zealand	222
11	Poland	217
12	Czech Republic	211
13	Saudi Arabia	209
14	America	203
15	Thailand	203
16	France	202
17	Russia	200
18	Spain	199
19	Cuba	197
20	Bulgaria	192
21	Georgia	190
22	Cameron	190
23	Italy	188
24	Canada	188
25	Chile	187

Rank	Country	Sustainability number
26	Mexico	186
27	Indonesia	186
28	Norway	180
29	Netherlands	179
30	UK	178
31	Romania	177
32	Greece	174
33	Bulgaria	170
34	Philippines	157
35	Armenia	155
36	Argentina	152
37	China	149
38	Tajikistan	144
39	Bahrain	144
40	Lebanon	143
41	Turkey	143
42	Ukraine	141
43	Iran	139
44	Jordan	138
45	General	133
46	Oman	132
47	Nigeria	132
48	India	131
49	Tunisia	130
50	Pakistan	129
51	Kyrgyzstan	128
52	Algeria	127
53	Mongolia	126
54	United Arab Emirates	125
55	Morocco	124
56	Egypt	123
57	South Africa	122
58	Kuwait	121
59	Diameter	118
60	Kazakhstan	117
61	Turkmenistan	116
62	Syria	114
63	Uzbekistan	112
64	Libya	110
65	Bangladesh	109

3. Results

Base on analysis of combined indices of 65 countries in 1990, three countries Venezuela, Germany and Austria with respective sustainability numbers of 356, 324 and 290 have the highest sustainability numbers and three countries Tajikistan, Mongolia and Egypt with respective sustainability numbers of 95,99 and 102 have lowest sustainability numbers and were at the bottom of the list.

Average number of sustainability for these countries was 167. In this list Iran's rank with sustainable number 141, were 40. That show poor performance in this area.

In 1995 the three countries, Venezuela, Germany and Austria have also topped the table and sustainability numbers for them respectively were 317, 238 and 219. Bangladesh, Egypt and Syria, respectively with sustainability numbers 81, 90 and 92 have lowest numbers. Average sustainability number of these countries in 1995 was equivalent to 139. Iran's rank with sustainable number 114, were 44. which was lower than the average of countries.

In 2000, still Venezuela, Germany and Austria, with sustainability numbers 364, 294 and 271 were at the top of the list and three countries Uzbekistan, Bangladesh and Libya, respectively with sustainability numbers 99, 102 and 103 were in the bottom of the list. Average sustainability number for the mentioned countries in 1995 was 166. Iran's rank with sustainable number 131, were 45.

In 2005, Venezuela and Germany still maintained their position and sustainability number for them are respectively, 358 and 304. In this year, Austria which was at the top of the list in the previous section, declines four steps down from the third to the seventh rank. Also in 2000, three countries, Bangladesh, Libya and Uzbekistan has been the worst performance and the sustainability number for them are 109, 110 and 112 respectively. Average of 65 countries is 172. In 2005, the stability number of Iran was 139, and its rank was 43, which is tow grade better in comparison with 2000.

As you can see, the average "sustainability indicators" have decreased in 1995 compared to 1990 (the number has reached 167 from 139) Bu tin 2000 and 2005 the number will increase (first 166 and then the number is 172) which expresses the fact that steps are taken toward seventh goal indexes by the countries and we hoped to achieve these goals. The objections against this indexes is that some developing countries are trying to reflect unrealistic information to international authorities to more to benefit from sources which usually provided to them by developed countries and UN organizations. Furthermore, based on composite indicators, some developing countries gain high stability number and have scored high, while the available evidence reveals other facts. For example Venezuela as a member of the Organization of Petroleum Exporting Countries, now is facing with many problems in the field of oil pollution resulting from exploration and exploitation of oil. One of the most important reason of high stability number for this country, using combined indexes, is high protected land area (with a value of more than 60%) and high area of the country's forest area (due to climatic and ecological conditions). In this way, and despite the structural problems of calculation of sustainability of seventh Millennium Development Goals, using composite indexes, this method can show the performance of the countries in the field of these goals. 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 countries 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 countries of the world is more important than the indicator of the ratio of area of land covered by forest to area of the country and therefore it is necessary, these indicators to be considered further and raised as Millennium Goals for that countries.

4. Conclusion

Environmental protection and maintaining its stability, emphasized on the Millennium Development Goal Seven, 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. Ensuring environmental sustainability, the seventh goal, which is explained based on three sub-goal and eight sub-indices (indices 25 to 32) and has been approved by the vast majority of countries, indicates a deep understanding of the international community of the importance of environment in achieving the other Millennium Development Goals and aspirations. In fact, many environmental problems that already plagued the international community is rooted in the ideals of the Millennium Development Goals. For example, the root of many environmental problems, especially in developing countries, arises due to poverty (MDG goal 1), because, more poverty, causes environmental degradation and environmental degradation on its own trigger more poverty and this vicious cycle can eventually lead in economic, social and environmental collapse. On this basis and in order to maintain life-sustaining systems of the earth and its resources, approaches and sources of production and consumption patterns must change in line with the ideals and goals of Millennium Development Goals in general and seventh goal in particular. After acceptance and approval of MDG indicators in 2000 by the international community, many attempts to achieve these objectives and policies began by the countries and subsequently, the need for methods to monitor and evaluate policies and programs to achieve these objectives in the form of composite indicators began. In this paper we tried to analysis and compare constituent indicators of seventh goal using composite indexes in four-period 1990, 1995, 2000 and 2005. On this basis, for 65 countries which have complete data,

combination index was calculated for the four sections mentioned above. Based on these rankings, developed countries (except Venezuela due to the high surface area of forests and protected areas) due to the higher stability number were at the top of the list and the poor and developing countries 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 Millennium Development Goals, to be supported more in the planning and policies of countries. Establishment of national committee and the provincial MDGs, promote popular participation and strengthening pro-environmental NGO, insert the Millennium Development Goals in various economic, social and environmental development programs, strengthen systems to collect statistics and information on the Millennium 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 countries can do to promote the goals of the seventh MDG goal. In response to international and regional challenges related to seventh goal of the Millennium Development Goals, 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 environmental protection (due to their high share in the exploitation of earth resources and more pollution emissions) 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 Millennium Development, especially goal seven. This issue, especially about environment, which is a public commodity, and therefore less incentive to invest in by people and countries are more important and need more support than other goals from the governments.

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