Re-Defining Sustainable Human Development to Integrate Sustainability and Human Development Goals

Hasnat Dewan, Thompson Rivers University, Canada

Abstract: Presently, human development and sustainability goals are mostly seen as independent goals. Sustainable Human Development (SHD) marginally considers environmental sustainability as a goal. This paper re-defines SHD, so the developmental goal is to achieve higher human development for the maximum number of people in present and future generations. Such a definition makes possible the convergence of two important goals: sustainability and attaining higher human development. This paper proposes a set of indicators and the conditions for SHD. The numerical values of the SHD conditions indicate if higher human development is achieved with sustainable means. Possible sustainable human development trajectories under different policy regimes can be derived from the primary SHD condition.

Keywords: Sustainable Human Development, Human Development Index, Sustainability, Sustainable Development

---

I am grateful to G. Liberatore and M. Young for their useful and constructive comments. All errors remain mine. Correspondence: Hasnat Dewan, Assistant Professor, Department of Economics, Thompson Rivers University, 900 McGill Road, PO Box 3010, Kamloops, BC V2C 5N3, Canada. Tel: 1-250-371-5986, Fax: 1-250-828-5051, Email: hdewan@tru.ca.

I. Introduction

The Human Development Index (HDI), developed by M. Haq, A. K. Sen, et al. in 1990 and popularized by the UNDP, is an alternate to conventional measures of economic development and human well-being. The limitations of HDI are well recognized.[1] Its computational methodology has evolved over the years and it has been supplemented with other indicators such as the Human Poverty Index (HPI), the Gender-related Development Index (GDI), and the Gender Empowerment Measure (GEM). Such measures capture disparity and other dimensions of social well-being. Changes in the stock of natural resources or the environment, however, are not directly included in the computation of any of these indicators. It has not been proven that any of these indicators has a monotonic relationship with the use of environmentally sound technology (EST) or social, economic, and environmental sustainability. In short, HDI, HPI, GDI and GEM are not intended to, and therefore do not, measure sustainability, though these indicators may very well be affected by the conditions of Natural and Social Environments (NSE).[2]

Even though sustainability ideas can be found in agronomic and ecological literature as early as 1949 (Leopold 1949, Carson 1965), the term *Sustainable Development* was first put forward by the World Conservation Strategy in 1980 (IUCN 1980). Later, the Brundtland Commission Report (1987) and the Rio Earth Summit (1992) made sustainable development a policy objective for the world community. Environmental sustainability is presently one of eight millennium development goals[3] that 191 UN member states have pledged to meet by 2015. Among numerous definitions[4] of

---

[1] M. Haq (1995) admits that HDI may be a "partial reflection of reality", but at the same time claims that it is "sharp and simple". It does not measure achievements in Sen's (1984) all "capability factors". Since HDI uses average life expectancy, it has been widely criticized for not considering the distributional issues (Sen 1993). Dewan (1998) showed that because of the then weighting scheme, the value of one year of life in HDI was US$101 (PPP) in 1996. McGillivray (1991), Hopkins (1991) and Srinivasan (1994) had questioned about the composition of HDI, the link between HDI and successful development, and the data quality respectively. Some of these issues have since been addressed.

[2] NSE includes the environment, natural resources, natural amenities, and socio-cultural, political and institutional conditions. Therefore, *natural and social capital* and what sociologists call *cultural capital* are part of NSE.

[3] Retrieved from http://www.un.org/millenniumgoals/ on 10/08/07

[4] Pezzy (1989) cited more than fifty definitions of *sustainability*. From numerous definitions, Jabareen (2008) identified seven different concepts of sustainable development.

sustainable development, the most cited is the Brundtland Commission's (1987) "very broad and non-specific"[5] definition, which is to "meet the basic needs of the present generation without compromising the ability of future generations to meet their needs."

There seems to be an apparent conflict between the sustainability and human development goals. Attaining higher human development may require the use of more resources, whereas ensuring sustainability may require constraining the use of resources and making some "defensive expenditures".[6] A balanced approach is, therefore, needed to optimize human development with sustainable use of natural resources and the environment. The term *Sustainable Human Development (SHD)* has been used since 1991 with different meanings, or as Cohen (1997) stated, "(t)here is no agreement among development practitioners as to what SHD is or is not …"

According to Jolly (1991), SHD means protecting our children's well-being with an "integrated, human approach to environment".[7] Speth wrote in the Foreword to the 1994 Human Development Report that SHD is

> development that not only generates economic growth but distributes its benefits equitably; that regenerates the environment rather than destroying it; that empowers people rather than marginalizing them. It gives priority to the poor, enlarging their choices and opportunities, and provides for their participation in decisions affecting them. It is development that is pro-poor, pro-nature, pro-jobs, pro-democracy, pro-women and pro-children.

According to Austin, "(s)ustainable human development is the process of improving practical needs and strategic interests to all members of a community with the intent of providing complete physical, mental and social well-being."[8] Hasegawa (2001) sees sustainable human development and environmental sustainability as two components of sustainable development. According to him, "SHD creates an environment in which human security is guaranteed and individual human beings can develop their full potential and lead a life of dignity and freedom."

---

[5] Retrieved from http://www.nirs.org/climate/cop6/powellcsdletter.pdf on 10/08/07
[6] Daly and Cobb (1989)
[7] Statement to the Third Session of UNCED Preparatory Committee, 1991. Quoted in Taylor-Ide and Taylor (1995)
[8] Retrieved from http://www.uib.no/epid/supercourse/lecture/lec1131/003.htm on 10/08/07

Each of these definitions of SHD brings different dimensions of human development goals to the forefront. Environmental sustainability is not the focal point of so-called SHD. Most in the Human Development paradigm sees sustainability as just another dimension of the human development goals, whereas the Sustainability paradigm considers that as the core issue for our future existence. This paper re-defines the concept of SHD by including social and environmental sustainability as well as the sustainability of human development objectives in the definition. Section II of this paper presents the new definition of SHD and a probable set of indicators to measure the sustainability of human development. Section III proposes a set of sustainability conditions to evaluate if higher human development is achieved with sustainable use of natural resources and the environment. It also shows how the basic sustainability condition can be used to derive sustainable human development trajectories for a country or a region under different policy regimes. Section IV presents the concluding remarks.

II. Definition and Indicators of SHD

Haq best explained the philosophy behind the Human Development paradigm, when he said:

> The basic purpose of development is to enlarge people's choices … People often value … greater access to knowledge, better nutrition and health services, more secure livelihoods, security against crime and physical violence, satisfying leisure hours, political and cultural freedoms and sense of participation in community activities. The objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives. (Haq, quoted in the 2006 Human development Report)

For human development to be sustainable, it must be ensured that it is achieved with sustainable means and the growth path of human development is non-negative. Climate change, deteriorated quality of environment, depletion of non-renewable natural resources, etc., are seen as potential threats to future sustainability. Therefore, all of these are real concerns for SHD. In an effort to find a comprehensive list of sustainability indicators, the UN Commission on Sustainable Development (UNCSD) has recently derived a core set of 50 indicators from its initial list of 134 indicators.[9] No such unique list of human development goals exists. The Human Development

[9] Retrieved from http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm on 10/08/07

Report (HDR) focuses on one "critical" issue every year and provides data on other "relevant" indicators.

According to the 2006 Human Development Report, safe water and sanitation problems are among "the most pressing challenges facing humanity". Other pertinent issues affecting present well-being are resources for and access to health services, nutrition, inequalities in maternal and child health, public spending on education, literacy and enrolment, technology, trade-aid-debt, public spending, unemployment, refugees, victims of crime, human and labour rights, etc. The concerns for the future generations, as identified in the report, are energy-use and the environment, which include traditional fuel and electricity consumption, CO_2 emission, bio-safety and diversity, and climate change.

Since there is no agreed definition of SHD, the list of indicators, even the emphasis on particular indicators, often varies from one study to another depending on the purpose of the study. According to the UNESCO, "the interdependent links between environment and development are not simply about conservation and economics, but also include a concern for issues such as human rights, population, housing, food security, and gender that are important parts of sustainable human development."[10] Hasegawa (2001) considers human development, poverty, security, human rights, gender empowerment, governance, etc., as the key issues for SHD; and ecosystem sustainability, biodiversity, climate change, environmental ethics as major components of environmental sustainability.

From Jamaican experience, Bloom, et al. (2001) point out, "… over the last 30 years, Jamaica has enjoyed some degree of human development, but unless growth occurs soon, that human development is unlikely to be *sustainable.*" Version 3 of the prototype SHD model built for Bangladesh[11] took human capital, education, health, income distribution and poverty, consumption

---

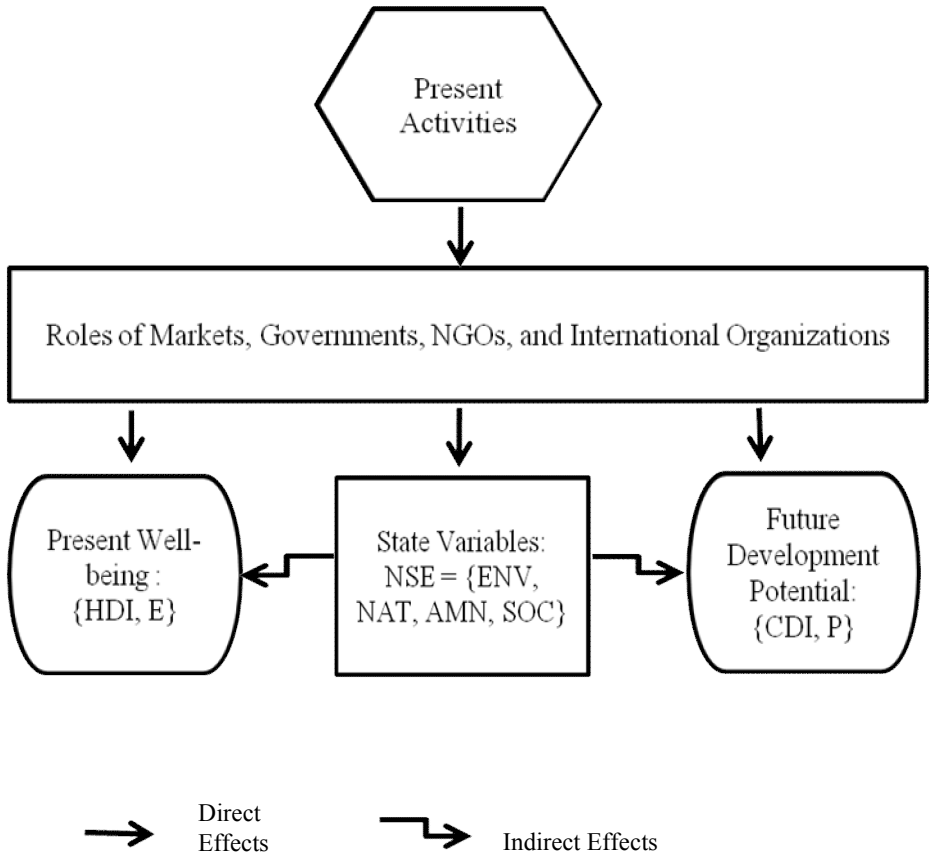
[10] Retrieved from http://portal.unesco.org/en/ev.php-URL_ID=4002&URL_DO=DO_TOPIC&URL_SECTION=201.html on 10/08/07

[11] The SHD model built for Bangladesh in 1995 was the first of its kind in the world. The model was made progressively more realistic by adding more variables and disaggregating different sectors. For the features of different versions of the SHD model, see http://www.iioa.org/pdf/15th%20Conf/ alarcon.pdf.

pattern and food security, and external debt into consideration. It did not, however, include "quantification of environmental considerations or those of local-level planning initiatives and programs" (Koesveld 2001).

From these various reports, papers and studies, it is possible to identify a tentative set of indicators for SHD. The objective in this section is not to list all indicators; rather an Analytical Framework (Figure 1) is proposed to show how all indicators can be put into three broad categories and how they can be aggregated to find six indices of SHD.[12] This framework is flexible enough to include or exclude any indicator according to the needs of a society.

Figure 1: An Analytical Framework



[12] In a report, prepared for the UN Division for Sustainable Development, Pinter, et al. (2005) recommended for using a "maximum of three to five indicators, related to high-priority policy issues" as a "pragmatic way forward".

Figure 1 shows that our activities, influenced by market and various other institutions, directly, or indirectly by changing Natural and Social Environments (NSE), affect both present and future well-being. Since the general objective of a human being on earth is to live a long and high quality life, indicators of longevity (L) and quality of life (Q) are good measures of human well-being. Two of the well-known quality of life and economic welfare indices include Measure of Economic Welfare (MEW) by Nordhaus and Tobin (1973) and Physical Quality of Life Index (PQLI) by Morris (1979). Mainstream economists use the level of consumption as a measure of economic welfare or material well-being (Nordhaus and Tobin 1973, Slesnick 1993). Disposable income, wealth and government spending among others define the opportunity set of people's consumption. Therefore, all of these variables are instrumental to determine L and Q, but they are not adequate. Besides economic, biological and medical factors, L and Q are also influenced by ecological, socio-cultural and institutional variables.

Determinants of Q include levels of private and public consumption, level of education, security of life, environment for flourishing human capabilities and potentials, liberty and freedom, and the environment. Education is listed separately from the consumption basket, because the social planner's valuation of education may be very different from an individual's valuation of educational attainment (Todaro and Smith 2006), and yet individual education has a significant social impact. Therefore, ensuring a minimum level of education for all is a social goal.

A healthy population is important for a sustainable society,[13] but, unlike education, if people can afford to, they are most likely to spend on health care as needed. Affordability and the quality

[13] "Health is …. critical to the level of security a population feels. As their chance of becoming sick decreases, and as the availability of services to care for them if they do fall ill increases, people are able to invest in the future with greater confidence, whether by purchasing education, setting up a business or saving for retirement. Lowering the risk of ill health, in other words, enables people to take other forms of risk that have greater benefit to society" (Bloom, et al. 2001). "The evidence from high prevalence countries in Africa who are experiencing more mature (HIV) epidemics is that growth rates of GDP may be reduced by 0.5 to 1.0 % per annum due to the epidemic" (Cohen 1997).

of health care can be issues of concern. There may be gender disparity in health care spending in some societies because of the absence of social safety net and/or other socio-economic factors. In any case, general health condition of a population is reflected in average longevity.

Therefore, the UNDP's Human Development Index (HDI) and an appropriately defined Equity Index (E) can be used to measure present well-being or L and Q. The HDI assigns two-third weight on income and education (or quality of life, Q) and one-third on longevity (L). Since consumption expenditure (C) is a major determinant of L and Q, HDI and C are expected to be highly positively correlated. Other determinants of Q, as stated above, are part of NSE in Figure 1.

It would be odd to make intergenerational equity a core issue in the sustainability concept, and ignore intra-generational equity altogether. Individual inequalities are certainly important, but unless people can identify themselves with a group, the failure can be attributed to personal incapability. Inequality among individuals may, or probably will, never be eliminated. Moreover, for variables such as life expectancy at birth, only group inequality matters (Sen 1993). Group inequalities need to be eliminated for the sake of a congruent society. Different measures of dispersion are used to compare inequality between groups and individuals in terms of income and opportunities.[14] Any such index must meet the Pigou-Dalton condition of transfer, which indicates that *ceteris paribus* any transfer from a relatively poor to a relatively rich person must increase the degree of inequality.

The following Equity Index (E) adequately measures group inequality in terms of human development, where groups are defined based on gender, race, ethnicity, religion and geographical region:

$$E = \left\{ \sum_{i=1}^{n} \left(H_{\max} - H_i \right)^{\beta} \left(P_i / P \right) \right\}^{1/\beta},$$

where H = HDI,

H_{max} = highest achievement in human development by a group,

[14] See Atkinson (1970), Rawls (1971), the HDR (2006).

H_i = human development of the i-th group,

(P_i/P) = relative population in the i-th group, and

β = inequality aversion parameter ($\beta \geq 1$).

This index meets the Pigou-Dalton condition of transfer for all $\beta > 1$ and it also ensures Rawlsian justice, which indicates that the fastest way to lower inequality is by improving the conditions of the most deprived group.

Ecological, institutional, and socio-cultural variables also affect people's quality of life. Hence, some measures of ecological variables as well as measures of a multitude of socio-cultural and institutional variables have been included in a set of indicators for quality of life.[15]

Following is a methodology to compute the Social Condition Indices (SOC_i) for different groups of people in a society:

$$SOC_i = 1 - \sum_{j=1}^{k} s_{ji} w_{ji},$$

where s_{ji} = the condition of social variable j evaluated by group i,

w_{ji} = assigned weight of social variable j for group i.

These indices are, then, aggregated to find a single SOC based on the size of population in each group. Therefore, $SOC = \sum_{i=1}^{n} SOC_i \left(P_i / P \right)$,

where P = total population,

P_i = population in group i.

This index is useful for understanding actual social conditions of various groups in a society.

---

[15] The social impact assessment techniques "in use tend to be relatively underdeveloped and require extensive expansion and basic conceptual and methodological development and analysis" (Leistritz and Murdock 1981). *Baseline profiling* is one of the methods used for social impact assessment. For a list of institutional indices, see Campos and Nugent (1999). Adelman and Morris (1973) say that the choice of a numerical scale for qualitative indicators may be arbitrary, but they claim that that does not "seriously invalidate" the results.

Social and economic sustainability are important, but due to climate change, extinction of species, projected exhaustion of non-renewable natural resources, and environment-related health effects environmental sustainability has presently become a major concern in many people's minds. Attaining higher human development by leaving too many "environmental footprints" cannot be considered sustainable human development in today's world. Sustainability condition requires that the damage to NSE due to developmental activities must not reach to a level so that it poses a threat to future human subsistence. Following is a method of computing the Damage Index:

$$DINSE = Max\{ENV, NAT, AMN, SOC\},$$

where DINSE = D = Damage Index for NSE,

ENV = an index for environmental damage,

NAT = an index for natural resource depletion,

AMN = an index for the destruction of natural amenities, and

SOC = an index for the change or degradation of social quality.

All indices are in [0, 1].

Among the sub-indices of DINSE, ENV is calculated based on land, air, noise, and water pollution. The critical levels and the weights of various components of ENV are determined based on available scientific knowledge. The weights of different contaminants are assigned based on their health effects and effects on bio-diversity. NAT is calculated based on per capita availability of natural resource stock. The weight of a natural resource in NAT is determined based on its contribution in the national economy and its availability. AMN is calculated based on all use and non-use values of natural amenities. The weight and the score of an amenity are assigned based on contingent valuation or bidding game technique and the current state of the amenity respectively.[16]

The justification for using the worst condition of a subsystem of NSE as the damage index is because each subsystem "has to have the capability to maintain its capability to survive and

[16] Detail computational methodologies for ENV, NAT and AMN are beyond the scope of this paper; rather the goal here is to present a conceptual framework only.

evolve" (Spangenberg 2005). Since the worst condition of a sub-system of NSE is used to calculate DINSE, it is necessary to monitor the Coefficient of Variation (V) of different damage indices.

One of the sub-systems of NSE, natural resources, are not only consumed, but are also transformed into new forms of capital such as infrastructure, housing capital, and other physical capital, which have positive welfare effects on both present and future generations. The present generation may also accumulate public debts, of which external debts *may* lower future well-being, while domestic debts will have only distributional effect. An index for the *future development potential* must account for all of these.

Produced capital, infrastructure, housing capital, foreign debts/lending, foreign reserves, productivity (technology + efficiency), etc., can partially measure future development potential; the rest being determined by present human development, other forms of capital, innovation, and technological progress. The following Capital-Debts Index (CDI) is a partial measure of future development potential:

$$CDI = \frac{\left[\left(k_p + k_i + k_r\right) - \left(D_b - L_x - R_x\right)\right]}{\left(k_p + k_i + k_r\right)} = \frac{k_m - D_x}{k_m},$$

where k_p = per capita produced capital,

k_i = per capita social overhead capital (infrastructure),

k_r = per capita housing capital (residential investment),

D_b = per capita foreign debts,

L_x = per capita lending,

R_x = per capita foreign reserves,

k_m = per capita produced capital, and

$D_x = (D_b - L_x - R_x)$ = per capita effective external debts.

Improvement in factor productivity and technology will offset some of the negative effects of the depletion of natural resources. Therefore, a Productivity Index (P), as defined below as the

current level of total factor productivity in a country compared to the maximum potential productivity can help understand the future development potential better.

$$P_t = \sum_{j=1}^{n} \left(\frac{a_{jt}}{m_{jt}} \right) w_{jt},$$

where a_{jt} = total factor productivity in industry j at time t,

m_{jt} = maximum potential productivity in industry j at time t, and

w_{jt} = weight of industry j in the GDP at time t.

Based on the above discussions, a tentative set of SHD indicators is defined as $\{HDI, E, DINSE, V, CDI, P\}$, because changes in these indicators can adequately capture changes in present and future well-being or human development. The next step is to set up a few conditions based on these indicators to ensure that the achieved level of human development is sustainable. Consequently, *Sustainable Human Development (SHD)* is defined as finding the optimum human development with minimum damage to NSE in order to promote the welfare of a maximum number of people in present and future generations. This can very well be the definition of *Sustainable (Economic) Development*, if economic development is defined as the growth of human development rather than the growth of the GDP.

III. Conditions for SHD

SHD is human development that can be sustained forever. Since natural, social and cultural capital are important determinants of the level of human development, and the depletion and deterioration of natural, social and cultural capital, biological resources and environmental quality or damage to NSE is the key sustainability concern, the SHD conditions must ensure the non-exhaustion of NSE until $t \to \infty$. Such conditions must also guarantee a non-declining stock of per capita natural resources and different forms of capital[17] to maintain a steady growth of human development.

[17] The Hicks/Lindahl requirement for sustainable income is non-declining value of the aggregate capital stock (per capita produced capital, k_p and per capita natural capital, k_n) over time. Therefore, Perrings (1996) defines an economy at any level of per capita produced capital (k_p) to

Least-DINSE *production* of human development is expected for sustainability. Based on the definition of SHD in section II and the above discussions, the primary SHD condition is defined in two possible scenarios as follows:

Scenario I: Improved human development at the cost of NSE

In this case, the ratio of a change in HDI to a change in DINSE has to ensure that NSE will never fall below the *critical levels* until targeted human development is reached. Targeted human development is continuously revised upward, following the UNDP's methodology, to guarantee a livable environment forever. Perceived risk parameter and discount factor can also be added to this condition. Hence, the primary condition for SHD is:

$$\left(\frac{\Delta H}{\Delta D}\right) \geq \frac{1}{1+\delta}\left(\frac{1-H}{1-D}\right)^{\frac{\gamma}{1-\gamma}} \qquad (1)$$

where H = HDI = the Human Development Index,

D = DINSE = Damage Index for NSE,

Δ = positive or negative change,

δ = the discount factor,[18] and

γ = the risk-aversion parameter.[19]

---

be sustainable, if $\Delta k_p \geq 0$ and $\Delta k_p + \Delta k_n \geq 0$ or $\Delta k_n/\Delta k_p \geq -1$. These conditions allow per capita natural capital (k_n) to decline over some finite time. This is consistent with the Solow-Hartwick framework (Solow 1974; Hartwick 1977, 1978), which is popular among economists and is termed as *weak sustainability condition* in the literature. The *strong sustainability condition*, on the other hand, assumes no substitutability between different types of capital. Pearce, et al. (1989, 1993) compute the *critical levels* of different natural capital to measure strong sustainability.

[18] An improvement in the present Human Development Index (H) may have some positive effect on the future H. This spill over benefit is captured by the non-negative fraction δ. Discounting future generations' benefits and costs is a key feature of economic models, and is often challenged by some as inconsistent with sustainability. See Faustmann (1849), Hotelling (1931), Mäler (1992), Friend (1992), and Schelling (1995) for different perspectives.

[19] The sustainability condition requires that the ratio of a change in H to a change in D be not less than $\frac{\gamma}{1-\gamma}$ order of the ratio of shortfall of H to the quality of NSE. The value of γ determines the *degree of bias* toward further human development or conservation of resources. Bias toward conservation means taking less risk about the future. Therefore, γ can be interpreted as the *risk-*

H, δ and γ are in [0, 1] and D is in [0, 1).

Re-arranging the terms, the sustainability condition can be written as

$$(1+\delta)\frac{\frac{\Delta H}{(1-H)^{\frac{\gamma}{1-\gamma}}}}{\frac{\Delta D}{(1-D)^{\frac{\gamma}{1-\gamma}}}} \geq 1 \text{ , or} \qquad (2)$$

$$(1+\delta)\left(\frac{\Delta H}{\Delta D}\right)\left(\frac{1-D}{1-H}\right)^{\frac{\gamma}{1-\gamma}} \geq 1 \qquad (3)$$

If the damage index relative to the HDI is too high, particular structure of the basic sustainability condition automatically puts more weight on the quality of NSE, making economic development difficult at the cost of further deterioration of environmental and social conditions and depletion of natural resources. With a higher state of development, a nation may value the quality of its NSE more. Such preferences are incorporated in the basic sustainability condition by assuming that $\gamma < 0.5 \ \forall \ H > D$ and $\gamma > 0.5 \ \forall \ H < D$.

The numerical value of the left-hand side of the expression (2) or (3) is called the Sustainable Human Development Index (SHDI) or simply the Sustainability Index (SI), since it can be used to assess and compare country performance as well as the performance of competing projects in terms of SHD. The primary SHD condition differs from the feasibility condition of Cost-Benefit Analysis (CBA), because the SHD condition does not require complete monetary valuation of all damages as does the feasibility condition of CBA; and there may not be a one-to-one relationship between monetary and physical damages. On the benefit side, changes to the human development index may not be proportional to the incomes generated from a project.

---

aversion parameter. γ can be computed *objectively* from the level of development and the *stocks* and the *critical levels* of resources, environmental quality and social conditions.

Scenario II: Environmental cleanup or improvement in NSE

Such an activity is expected to increase present and future well-being, therefore, some loss in H is acceptable as long as

$$\left(\frac{\Delta H}{\Delta D}\right) \leq \frac{1}{1+\delta}\left(\frac{1-H}{1-D}\right)^{\frac{\gamma}{1-\gamma}} \tag{4}$$

Re-arranging the terms, the SHD condition can be written as

$$(1+\delta)\frac{\frac{\Delta H}{(1-H)^{\frac{\gamma}{1-\gamma}}}}{\frac{\Delta D}{(1-D)^{\frac{\gamma}{1-\gamma}}}} \leq 1, \text{ or} \tag{5}$$

$$(1+\delta)\left(\frac{\Delta H}{\Delta D}\right)\left(\frac{1-D}{1-H}\right)^{\frac{\gamma}{1-\gamma}} \leq 1 \tag{6}$$

The primary SHD condition is *necessary, but not a sufficient condition* for sustainability, since (1 - D) is not inclusive of all *factors of production* of human development. This condition ensures that natural, social and cultural capital will not constrain the future development unreasonably. There may, though, be constraints due to the lack of produced and human capital. The conditions, ΔCDI and $\Delta P \geq 0$ are adequate to take care of that concern. The negative effect of population growth rate is captured by CDI along with other indicators. To ensure intra-generational equity, $\Delta E \geq 0$ is also added as a sustainability condition. Since D can improve while the average of the sub-indices may deteriorate, $\Delta D_{average} \leq 0 \ \forall \Delta D < 0$, in addition to changes in the Coefficient of Variation, $\Delta V \geq 0 \ \forall \Delta D \geq 0$ and $\Delta V < 0 \ \forall \Delta D < 0$ is added as a condition.

Another condition to add on the list of *sufficient conditions* for sustainability is:

$$\sum_{t=0}^{T\to\infty}(\Delta D_t) \leq (1-D_0) \tag{7}$$[20]

[20] If continuous change is assumed, this condition can be written as

Assuming a large value of T based on risk-perception of the present generation, maximum allowable ΔD in a period can be calculated as $\Delta D \leq (1-D)/T$. [21] It has to be revised periodically depending on changing technology, new discoveries, and the availability of new information to minimize errors.

Hence, the proposed set of conditions for SHD is:

(1) $SI \geq 1 \ \forall \Delta D \geq 0$ and $SI \leq 1 \ \forall \Delta D < 0$

(2) $\sum_{t=0}^{T\to\infty}(\Delta D_t) \leq (1 - D_0)$

(3) $\Delta CDI, \Delta P, \Delta E \geq 0$

(4) $\Delta V \geq 0 \ \forall \Delta D \geq 0$; $\Delta V < 0$ and $\Delta D_{average} \leq 0 \ \forall \Delta D < 0$

Various degrees of sustainability can be defined based on partial fulfilment of these conditions. The SHD conditions guarantee the attainment of targeted human development without completely destroying the quality of NSE, where NSE includes both social and ecological variables. The sustainability condition, $\Delta E \geq 0$, ensures equity. Therefore, meeting the proposed sustainability conditions ensures economic and social as well as ecological sustainability as advocated by Serageldin (1995). The SHD conditions, by putting additional constraints on resource-use, cause the society to bear some deadweight loss. It is consistent with the postulate that both sustainability and efficiency goals are not achievable simultaneously (Solow 1974, Hartwick 1978, Norgaard 1992).

$$\int_{t=0}^{T\to\infty} dD_t \leq (1 - D_0) \Rightarrow \int_{t=0}^{T\to\infty} \frac{dD_t}{(1 - D_0)} \leq 1 \Rightarrow \left(\frac{D_{T\to\infty} - D_0}{1 - D_0} \right) \leq 1.$$

[21] *The Limits to Growth* (1972) and *Beyond the Limits* (1992) give some time frame for the exhaustion of natural and environmental resources based on static models. According to mainstream economists, such "static reserve index underestimates by a dramatic margin the time until exhaustion" (Stavins 1992) due to its failure to recognize the role of technological progress, new innovation and discoveries, substitution possibilities and price adjustment mechanism (Nordhaus 1992). Stavins, however, says that the *Limits* prophecy makes sense for biological resources, such as species.

Assuming continuous changes to H and D, the primary SHD condition can be defined in terms of a differential equation as follows:

$$\frac{dH}{dD} \geq \frac{1}{1+\delta}\left(\frac{1-H}{1-D}\right)^{\frac{\gamma}{1-\gamma}}, \text{ or}$$

$$\int \frac{dH}{(1-H)^{\frac{\gamma}{1-\gamma}}} \geq \frac{1}{1+\delta}\int \frac{dD}{(1-D)^{\frac{\gamma}{1-\gamma}}}, \text{ or}$$

ζ (1-H) $\leq$ (1-D), where ζ is a constant in terms of γ and δ.

Using the marginal condition, or equality, this equation can be solved for different values of the choice variables and can be plotted to find SHD trajectories. The implications of positive discounting and various risk perceptions on sustainability of human development can be assessed based on these trajectories.

IV. Conclusion

Meeting the proposed SHD conditions ensures the sustainability of human development. The numerical value of SHDI indicates if higher human development is achieved with sustainable means. One of the conditions, the Equity Index, measures regional, gender-related, racial, ethnic and religious disparity in terms of human development. The Human Development Index (HDI), the Human Poverty Index (HPI), the Gender-related Development Index (GDI), and the Gender Empowerment Index (GEM) measure different dimensions of human development goals. This paper is not intended to question the importance or the relevance of any of these indices. Rather it is expected that the proposed conditions will supplement them to ensure sustainability of human development. The proposed definition of SHD is consistent with the Brundtland Commission's definition of sustainable development, except that here the developmental goal is to achieve higher human development for the population. This definition makes possible the convergence of two important goals of today's world community, sustainability and attaining higher human development. The formulae provided can be subjected to empirical testing with micro or macro

level data. We must act to assure a sustainable, optimized, level of economic and human development for our citizens, our children, and future generations. The task is important. The timing is urgent.

References

Adelman, I. and C. Morris (1973). *Economic Growth and Social Equity in Developing Countries*. Stanford University Press, Stanford.

Atkinson (1970). On the measurement of inequality. *Journal of Economic Theory,* Issue 2, pp. 244 - 263.

Bloom, et al. (2001). Globalization, Liberalization and Sustainable Human Development: Progress and Challenges in Jamaica. Occasional Paper No. 176, UNCTAD/ UNDP.

Brundtland Commission (1987). *Our Common Future*. Oxford University Press, Oxford.

Campos, N. and J. Nugent (1999). Development Performance and the Institutions of Governance: Evidence from East Asia and Latin America. *World Development*, Elsevier, vol. 27(3), pages 439-452.

Carson, R. (1965). *Silent Spring*. Penguin, Harmondsworth.

Cohen, D. (1997). The HIV Epidemic and Sustainable Human Development. Issues Paper No. 29, HIV and Development Programme, UNDP.

Daly and Cobb (1989). *For the Common Good: Redirecting the Economy towards the Community, the Environment and a Sustainable Future*. Beacon Press.

Dewan, A. H. (1998). Measuring Sustainable Development: Problems and Prospects, Ph.D. dissertation, The University of Texas, Austin.

Faustmann, M. (1849). Berechnung des Werthes, welchen Waldboden sowie nach nicht haubare Holzbestande fur die Weldwirtschaft besitzen. *Allgemeine Forst und Jagd Zeitung* 25.

Friend, A. M. (1992), in UNEP. *Summary Record: Workshop on Environmental and Natural Resource Accounting.*

Haq, M. (1995). *Reflections on Human Development.* Oxford University Press, USA.

Hartwick, J. M. (1977). Intergenerational Equity and the Investment of Rents from Exhaustible Resources. *American Economic Review*, 67, December, pp. 972-74.

Hartwick, J. M. (1978). Substitution among exhaustible resources and inter-generational equity. *Review of Economic Studies* 45.

Hasegawa, S. (2001). Development Cooperation. UNU Global Seminar on Global Issues and the United Nations, Nov 20, 2001.

Hopkins, M. (1991). Human development revisited: A new UNDP report. *World Development*, Vol. 19, No. 10.

Hotelling, H. (1931). Economics of Exhaustible Resources. *Journal of Political Economy* 39.

IUCN/UNEP/WWF (1980). *World Conservation Strategy: Living Resource Conservation for Sustainable Development*.

Jabareen, Y. (2008). A New Conceptual Framework for Sustainable Development. *Environment, Development and Sustainability* 10, pp. 179-192.

Koesveld, E. (2001). Sustainable Human Development Model in Bangladesh: A Background Note, prepared for the UNDP regional seminar on Macroeconomic Policy Analysis and Modeling in Tashkent, Uzbekistan, 20-22 June 2001.

Leistritz, F. and S. Murdock (1981). The Socioeconomic Impact of Resource Development: Methods for Assessment. Social Impact Assessment Series, No. 6. Westview Press, Boulder.

Leopold, A. (1949). *A Sand County Almanac*. Ballantine Books, New York.

Mäler, K-G. (1992), in UNEP. *Summary Record: Workshop on Environmental and Natural Resource Accounting.*

McGillivray, M. (1991). The human development index: Yet another redundant composite development indicator? *World Development*, 19 (10), pp. 1461-1468.

Meadows, et al. (1972). *The Limits to Growth*. Universe Books, New York

Meadows, et al. (1992). *Beyond the Limits*. Post Mills, Vennont: Chelsea Green Publishing Company.

Morris, M. D. (1979). *Measuring the Condition of the World's Poor: The Physical Quality of Life Index*. Pergamon, New York.

Nordhaus, W. D. and J. Tobin (1973). Is Growth Obsolete? in Moss, M. (Ed.). *The Measurement of Economic and Social Performance: Studies in Income and Wealth,* Vol. 38.

Nordhaus, W. D. (1992). Lethal Model II: The Limits to Growth Revisited. Brooking Papers on Economic Activity, 1992:2.

Norgaard, R. (1992), in UNEP. *Summary Record: Workshop on Environmental and Natural Resource Accounting.*

Pearce, D., et al. (1989). *Blueprint for a Green Economy*. Earthscan, London.

Pearce, D., et al. (1993). *World without End: Economics, Environment and Sustainable Development.* Oxford University Press.

Perrings, C. (1996). Ecological Resilience in the Sustainability of Economic Development, in Faucheux, S. et al. (Eds.). *Models of Sustainable Development*, London, Edward Elgar: 231-252.

Pezzy, J. (1989). Definitions of Sustainability. CEED Discussion Paper No. 9, The UK Centre for Economic and Environmental Development, Cambridge.

Pinter, et al. (2005). Sustainable Development Indicators: Proposals for the Way Forward, prepared for the UN Division for Sustainable Development, IISD.

Rawls, J. (1971). *A Theory of Justice*. The Belknap Press of Harvard University Press.

Schelling, T.C. (1995). Intergenerational discounting. *Energy Policy*, 23 (4/5): 395.

Sen, A. (1984). *Resources, Values and Development*. B. Blackwell.

Sen, A. (1993). Life expectancy and inequality: Some conceptual issues, in Bardhan, P., et al. (Eds.). *Development and Change.*

Serageldin, I. (1995). *Sustainability and the Wealth of Nations: Preliminary Draft*, World Bank.

Slesnick, D. (1993). Gaining Ground: Poverty in the Post-war United States. *Journal of Political Economy*, Vol. 101, No. 1.

Solow, R. M. (1974). Intergenerational equity and exhaustible resources. *Review of Economic Studies*, Vol. 41, supplement.

Spangenberg, J. H. (2005). Economic sustainability of the economy: concepts and indicators. *International Journal of Sustainable Development*, Vol. 8, No. 1/2.

Srinivasan, T. N. (1994). Human Development: A New Paradigm or Reinvention of the Wheel? *The American Economic Review*, Vol. 84, No. 2.

Stavins, R. (1992). Comments on 'Lethal Model 2: The Limits to Growth Revisited' by William Nordhaus. Brookings Papers on Economic Activity, No. 2, pp. 44-50.

Taylor-Ide, D. and C. Taylor (1995). Community Based Sustainable Human Development. Primary Environmental Care (PEC) Discussion Papers on Children, Environment and Sustainable Development, No. 1, Feb 1995.

Todaro, M. and Smith, S. (2006). *Economic Development*, 9th edition, Pearson Addison Wesley, pp. 383-386.

UNDP. *Human Development Report*, various issues.

UNEP (1992). *Summary Record: Workshop on Environmental and Natural Resource Accounting.*

http://www.future.org/downloads/greenbook.pdf.

http://www.iioa.org/pdf/15th%20Conf/alarcon.pdf.

http://www.nirs.org/climate/cop6/powellcsdletter.pdf.

http://www.uib.no/epid/supercourse/lecture/lec1131/003.htm.

http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm.

http://www.un.org/millenniumgoals/

http://www.unctad.org/en/docs//poedmm176.en.pdf.

http://www.unescap.org/drpad/projects/casia/uzb_bgl.doc.

http://portal.unesco.org/en/ev.php-URL_ID=4002&URL_DO=DO_TOPIC&URL_SECTION=201.html.

http://www.unu.edu/hq//japanese/gs-j/gs2001j/kanazawa1/Lec5-text-e.pdf.