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ON THE SUSTAINABILITY OF ETHIOPIAN ECONOMY

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ABSTRACT

Comprehensive wealth growth rates, the ratio of comprehensive investment to real GDP, and the gap between gross and comprehensive investment ratios were used to assess the sustainability of Ethiopian economy from 1990 to 2008. The average per capita comprehensive wealth growth rate was 0.55% and -1%, respectively, with and without human capital investment considered. However, both growth rates are lower than the 2.2% baseline scenario (per capita real GDP) growth rate. The results imply that economic policies should be integrated with demographic and environmental policies. It is through the integration of these policies that the robust economic growth rate achieved for the last seven consecutive years in the country can overwhelm the rents from the depletions of forests, minerals, and damages due to global and local environmental externalities.

Keywords: Sustainable Development, Comprehensive Investment, Wealth Accounting, Inter-temporal welfare, Harrod-Domar growth model, Ethiopia

INTRODUCTION

The Ethiopian economy performed poorly in the first fifteen years (an average of 2.8% for 1990 - 2003) of the new political and economic regime. Ethiopia is also documented to be a nation with a lowest per capita comprehensive wealth out of 200 countries in 2000 (World Bank, 2006). However, Ethiopia is enjoying a double-digit economic growth for the last seven consecutive years (World Bank, 2009).

On the other hand, population is increasing along with which pressure on the natural resources base increases in the country. It is also clear that environmental problems (e.g. air pollution and water pollution) to increase with economic transformation and rapid rate of urbanization in the country. Partially due to its heavy dependence on most weather sensitive economic sector (i.e. agriculture) for both subsistence and foreign exchange earnings; and partially due to its low financial and technical adaptation capacity to cope up with this global negative externality; there is also a formidable threat to the Ethiopian economy from global warming and the resulting climate change.

With such conditions, confining oneself to the conventional measures of welfare (e.g. Gross Domestic Product (GDP) and its growth rate) to assess the macroeconomic performance of Ethiopia will be deceiving. Better and wider measures of human welfare should be used.

The notion of sustainable development, which is commonly (but broadly) defined as a development path that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987:43) emerged as a guiding principle of economic growth and development in the mid 1970s. Sustainable development requires investments in all forms of capital to be considered. Sustainable development puts high economic growth rate (as measured by a year to year change in real GDP) as only a necessary condition for sustained improvement in human welfare. High conventional economic growth rates can be used as indicator of sustainable economic growth if and only if the growth is able to compensate the rents from the depletion of natural resources and damages due to environmental externalities.

This paper employs the very recent economic approach of sustainable development, comprehensive wealth accounting, to assess the sustainability of Ethiopian economy for the period 1990 to 2008. For the sake of having clear picture on which type of capital contributes more to the sustainability of the economy, three alternative scenarios – comprehensive wealth growth rates including human capital investment (Scenario1), comprehensive wealth growth rate excluding human capital investment (Scenario 2) and real GDP growth rate (baseline scenario) – were constructed. The results show that the Ethiopian economy scored positive average per capita growth rates under Scenario1 and the baseline scenario in the survey period. While the share of human capital investment in real GDP was high and relatively volatile; the share of rents from forest and mineral depletions and damages due to global carbon emission and particulate matters were almost stable throughout the survey period. Therefore, along with high population growth rate which averaged 2.97%, it can be argued that the per capita growth rates under all scenarios were unsatisfactory. The striking observation, however, is that there is non-converging gap between the gross investment ratio (GIR) and comprehensive investment ratio under scenario 2 (CIR_2).

Taken together, the results imply that Ethiopia ought to integrate its environmental, demographic, and economic policies for better economic growth that leads to sustained improvement in human welfare over time.

The rest of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature of sustainable development. Section 3 presents the measurements along with the results of different variables included in the paper. Section 4 discusses the results and draws their implications for the sustainability of Ethiopian economy. Section 5 concludes the paper.

LITERATURE REVIEW

The Concept of Sustainable Development

Sustainable development, in broader sense, is a way to meet the economic, social, and political needs of the current generation at minimum resource depletion, environmental degradation, and socio-cultural disruptions (Barbier, 1998; SEEA, 2003). Nevertheless, there is no universally agreed single definition for the term sustainable development for two main reasons. First, the dimensions of sustainable development are many. It is concerned with ecological, social, economic, political, and cultural aspects. Different fields of study take this advantage and define and measure sustainable development differently (Moffatt, 1996). Hence, there may be different sets of criteria and indicators being used as indicators of sustainable development. In this paper, however, we will focus on the definition, measurement, criterion, and indicators of sustainable development from economists' point of view only. Second, sustainable development is not just about present, but about the link between present and future.

Nonetheless, sustainable development commonly refers to a development path that "meets the needs of the current generation without compromising the ability of the future generations to meet their own needs and wants" (WCED, 1987: 43). More specifically, sustainable development requires each generation to bequeath to its successor at least as large a productive base as it inherited from its predecessor (Dasgupta and Maler, 2000).

Sustainability is different from efficiency and optimization (Moffatt, 1996; Pearce and Atkinson, 1998; Tietenberg, 2003). Thus, new set of variables should be considered and new methods need to be employed in assessing inter-temporal human welfare and its sustainability. Therefore, the indicators of sustainable development are different from the conventional welfare indicators such as GDP, real GDP growth rate, per capita income (PCI) and the likes.

Economists use the "weak" sustainability rule; according to which sustainable development refers to non-declining productive base (i.e. total capital which is the sum of physical, human, natural capital, and recently social capital). The rents from natural resources should be reinvested in reproducible and human capital to ensure sustainable development. Put another way, the change in physical capital is required to "either 1) to eliminate the need for a particular natural capital service or 2) find a means of replacing the natural capital service with a service of produced capital" (SEEA, 2003:5). Weak sustainability rule is also known as capital approach of sustainability. This definition and approach of sustainability leads us to the measuring sustainable development from economists' point of view.

Indicators of Sustainability

Genuine savings (GS) is the often-cited economic measure of sustainable development. The origin of GS goes back to Pearce and Atkinson (1993) and now it is widely associated with the World Bank. GS is an extension of the traditional saving with adjustments to natural resources depletion, damages from pollution and human capital formation. The depletion in the natural resources and damages due to carbon emission and very recently damages from particulate matters (PM_{10}) will be deducted from the sum of net human capital formation (approximated by current expenditure on education) and the conventional net savings (physical capital investment less depreciation of it). If the total wealth (productive base) is given by the sum of different capital assets valued at their respective shadow price, GS is given by sum of *changes* of real values of these different capital assets. The World Bank then uses the ratio of GS to Gross National Income (GNI) as indicator of sustainable development.

The GS approach, however, fails to consider the exogenous effects imposed by population and technological changes on productive base. Per capita wealth will be declining if population is growing. Technological (and institutional) change augments the productivity of different capital assets. Measuring disinvestment in different natural capital assets (e.g. damages due to local carbon emission only) and human capital formation (taking current educational expenditure as a proxy) are also theoretically inconsistent (Arrow et al., 2007).

Arrow et al. (2004) and Arrow et al. (2007) come with an alternative capital (economic) approach of sustainable development dubbed as “comprehensive wealth” perspective. Arrow et al. (2007) have made many important advances in the arena. First, they have considered the effects of population growth and technological change. Second, they introduced the issue of capital ownership by residents of a given nation to which effect the physical capital stock of a nation should be adjusted for *net* international holdings. Third, they applied more theoretical consistent measure of human capital (based on educational attainment and health) and damages due to carbon emission (based on global emissions than national emission).

Sustainability Criterion

Sustainability brings the future with the present. On the other hand, “development” being substituted by an economic term “increased utility”: sustainable development refers to “a development path that ensures non-decreasing per capita utility” (Pearce and Atkinson, 1998:1). Taken together, therefore, a measure of sustainability should emphasise on inter-temporal welfare (Arrow et al., 2004; Arrow et al., 2007; Ollivier and Giraud, 2009). Inter-temporal welfare of current generation is a function of both the current utility (which itself is function of current consumption) and its care to the future generations (Arrow et al., 2007: Ollivier and Giraud, 2009). Non-declining inter-temporal welfare is possible through maintaining or increasing productive base (Arrow et al., 2004). The Arrow et al. (2007) conceptual approach is given below. Let V stands for inter-temporal welfare:

$$Vt = \int_t^{\infty} e^{-\rho(s-t)} \; U[C(s)]ds \quad \text{...} \quad (1)$$

Where, **t**= time, **ρ** = [subjective] social time preference (or simply discount rate of social utility), **U**= utility at any point of time, and **C** = a vector of consumption that consists of marketed and non-marketed (amenity values from the natural environment, for example) goods and services, and health dimensions. Sustainability, then, requires the change in V (presented in equation 1) to be greater than or equal to zero at each point of time.

$$\frac{dV}{dt} \geq 0 \quad \text{.......... (2)}$$

Taken together, consumption (and hence utility and welfare), hinges on two main things: on the economy's present productive base, and the allocation of resources between investments and consumption. The allocation may be guided either by optimality or by exogenous rules, which in turn makes the allocation non-autonomous (Arrow et al., 2004). Suppose, as in standard economic growth theories, there is single output that can either be consumed or added (invested) to the productive assets. Thus, each future capital stock is determined by this allocation rule and its respective current capital stock. It does mean, as in the equation below, both the values of K_{it} and C_t are determined by all future time periods, $s \geq t$, and by time *t* itself. Both U[C(s)] and hence V_t are determined by all $s \geq t$ and allocation of resources at *t*, which is due to exogenous factors. Exogenous factors include an exogenous technological or institutional change, global public good or bad, capital gains, population change, and uncertainty (Dasgupta, 2009 cited in Ollivier and Giraud, 2009). Exogenous technological (and institutional) change, population change, and global public bad (damages from global environmental externalities such as carbon emissions) are attempted to be incorporated in studies to date.

$$V_t = [K_P (t), K_H (t), K_N (t), t] \quad \text{.......... (3)}$$

Where, the subscripts represent for the type of capital – *P* for physical, *H* for human and *N* for natural capital. The change in V_t, then, yields comprehensive (genuine or inclusive) investment:

$$\frac{dV}{dt} = \frac{\partial V}{\partial Kp}\frac{dKp}{dt} + \frac{\partial V}{\partial Kn}\frac{dKn}{dt} + \frac{\partial V}{\partial Kh}\frac{dKh}{dt} + \frac{\partial V}{\partial t} > 0$$

Or .... (4)

$$\frac{dV}{dt} = \sum \frac{\partial V}{\partial Ki}.\frac{dKi}{dt} + \frac{\partial V}{\partial t} > 0$$

Where, i=P, H, or N, and $\frac{dV}{dt}, \frac{\partial V}{\partial Ki}, \frac{dKi}{dt}$, and $\frac{\partial V}{\partial t}$, respectively denote change in real wealth (comprehensive investment), shadow price of capital *i* (marginal increase of inter-temporal welfare due to a unit increase in a stock of capital *i*), net investment in capital *i*, and the impact of exogenous factors respectively. Let now q_i and I_i respectively stands for shadow price (measured in monetary values) and net investment in capital *i*. Thus, we can rewrite equation 4 as:

$$\frac{dV}{dt} = \sum qiIi + \frac{\partial V}{\partial t} \quad \text{.......... (5)}$$

Equation 5 represents comprehensive investment (CI) adjusted for environmental externalities. Therefore, if total wealth (or productive base) represents social welfare at a given point of time (i.e. V_t), the change in total wealth (i.e. comprehensive or inclusive/genuine investment) will show the sustainability of this welfare overtime.

Empirical review

The first cross-country application of greener accounting methods, *net savings criterion*, was used in Pearce and Atkinson (1993) on 20 countries by combining estimates of depletion and degradation of natural capital with standard national accounting data. Many countries appear to be unsustainable because their gross (conventional) savings are less than the combined sum of conventional capital depreciation and natural resource depletion in the countries (Hamilton and Clemens, 1999).

Many studies that followed the GS approach document that the Sub-Saharan Africa region stands out as the region where the greatest dissipation of wealth is occurring (c.f. Hamilton and Clemens, 1999; World Bank, 2006). Average genuine saving rate of the region rarely exceeded five percent of Gross National Product (GNP) during the 1970s, followed by a sharp negative turn at the end of that decade from which 12 of them have never recovered (Hamilton and Clemens, 1999).

Arrow et al. (2007) used the 'comprehensive wealth' perspective to assess the sustainability of the United States of America and Chinese economy between 1995 and 2000. They find that an average per capita comprehensive growth rate of 1.45% and 3.18% per annum, respectively, for USA and China. The positive growth rates were mainly due to increasing human capital investment; positive growth rate of total factor productivity; and increasing forest plantation in both nations (Arrow et al., 2007). Ollivier and Giraud (2009), employing more or less the same methodology with Arrow et al. (2007) and accounting soil degradation and overfishing, showed that the Mozambican economy to be sustainable for the period between 2000 and 2005 (4.6% per annum) unlike many Sub-Saharan nations. The rate was mainly due to fast growing physical capital and human capital investments at less natural resource pressure (Ollivier and Giraud, 2009).

The World Bank (2009) estimates the average genuine savings (as % of GNI) of Ethiopia (1990-2008) to be 4.56% with maximum of 13.08% in 2007 and minimum of -0.88% in 1992. The figures show that, though not to talk much about, the Ethiopian economy was following almost a sustainable development path in the last two decades. The results, however, should be interpreted cautiously as the Ethiopian economy is with no rents from exhaustible energy resources. On the other hand, the World Bank (2006) which stretches the wealth account to include subsoil assets, pasturelands, croplands, non-timber values of forests, protected areas, the value of urban land, and intangible assets reports Ethiopia to be a nation with lowest per capita comprehensive wealth ($US 1, 965 at 2000 prices) in the year 2000 out of 200 countries included in the report. Moreover, World Bank (2006) documents that the per capita natural capital ($US 796) is four times larger than the per capita physical capital ($US 177) in Ethiopia. The rest $US 992 is per capita intangible assets (World Bank, 2006). The World Bank (2006) estimates show us that the issue of sustainability and sustainable development is not an alternative to Ethiopia but a prior goal.

In spite of the palatable progress in both the theory and empirics of sustainable development, however, there are still some gaps in the economic literature that remain intact for the last three decades. From the 'extreme' weak sustainability approach (i.e. Hartwick rule) to the most recent 'comprehensive wealth' approach, the notion of substitutability fails to incorporate the economic consequences due to loss in ecosystem resilience and natural environment degradation (Barbier, 1998). In addition to problems related to valuation of natural assets (as most of them are non-marketed), some natural assets (soil, for example) are not treated well in the literature so far. Nor the economic and ecological values of forests are accounted well. Of course, uncertainty complicates the measurement issue more. There is also ongoing debate on the role of population and technological change on sustainable development (Pearce and Atkinson, 1998). The debate is akin to the debate on economic growth theories – whether technological and population change is endogenous (as in endogenous growth theory) or exogenous (as in neo-classical growth theory). The marginal social damages due to climate change are still controversial. The damages due to carbon emission and climate change are still based on conservative climate change scenario (only 2.5^{o}c of global warming). Some of the gaps, however, are due to data limitations. Consider the case of fishery and diamond, for example. It is hardly possible to measure the stock of fishery in a given nation due to the mobility nature of fish. Data related to diamond is kept privately by mining companies. Damages due to air pollution (both indoor and outdoor), water pollution, and hazardous solid wastes are yet to be subsumed due data availability (Arrow et al., 2007).

MEASUREMENTS AND RESULTS

Equation 5 in the earlier section breeds two main steps in measuring the *change* in inter-temporal welfare. First is to calculate the variations (investments) in different capital assets and then to consider the effects of changes in exogenous factors affecting the welfare such as population growth.

Measuring investments and disinvestments in capital assets

Physical (reproducible) capital investment

Physical capital refers to produced (manufactured) assets that can be used to produce other goods and services and is capable of generating income. The change in physical capital stock is what we commonly call as gross physical capital formation (or investment). According to the World Bank, gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress."

The gross physical capital investment (or the gross capital formation) was retrieved from the World Bank (2009). Then, a linear 5% rate of depreciation (as in World Bank (2006) and many other studies) was assumed. The net physical investment, IP_t, is then:

$$iPK_t = (GCF_t – Depreciation_t) = 0.95GCF_t \text{.................................... (6)}$$

Column 2 of Table 3, in the Appendix, summarizes the physical capital formation in Ethiopia for the survey period. The values (and any values given in this paper) are at 2000 USD. As one could expect, the investment in physical capital in the country tracks the real GDP figures given in Table 1.

Human capital investment

The knowledge, skills, competences, other attributes embodied within individuals helps them to generate stream of income as any other form of capital can do. Therefore, human capital should be computed based on both educational attainment and remaining years of working. Assuming perfectly competitive labour market, so that the marginal product of human capital equals the wage being paid, the value of human capital stock at time *t* is:

$$HK_t = P_{h*}H_t \quad (7)$$

Where, HK_t= value of human capital stock at time *t*, P_h = shadow price of a unit human capital, and H_t= total stock of human capital, which in turn is given by:

$$H_t = Le^{rA} \quad (8)$$

Where, *L*=working population, *A* =average years of schooling (or educational attainment) of working population, and *r* = the rate of return of education. We cut off those above 15 years old as working population, as in a standard labour and development economics theories. It is given in Table 2. The data for the same is retrieved from International Data Base in the US Census Website. Average educational attainment for Ethiopia is hardly available. Neither of the World Bank Education Stat, UNESCO Educational Stat, and the Barro –Lee data of educational attainment estimated the educational attainment in Ethiopia. Nor there are local data sources and studies on the same. Therefore, we were compelled to take the Sub-Saharan average educational attainment from Barro-Lee Educational Attainment Dataset Website. The Barro-Lee educational attainment is available only for the years 1990 (3.86), 1995 (4.35), 2000 (4.67), 2005 (5.07), and 2010 (5.45). Therefore, we assumed a linear annual growth for the years in between so that we can have average educational attainment from 1990 to 2008.

The World Bank (2006; sourcing Psacharopoulos and Patrinos, 2004) estimated the average social return of investment in education in low-income countries to be around 16%. Ollivier and Giraud (2009) sourcing Psacharopoulos (2004) claimed that the social return to education in Mozambique and in the region to be 12.5 %. In balance, therefore, we found taking 13% social return of education in Ethiopia reasonable. This return is also assumed to be constant in the survey period.

The shadow price of each unit (individual's) of human capital, on the other hand, is given by:

$$P = \int_t^{t+m} w.e^{-\rho t} dt \quad (9)$$

Where, *w* = the annual rental value of a unit of human capital, *ρ* = the social discount rate, and *m* = the average remaining years of working till retirement or death. In principle, the rental value, *w*, is given by the ratio of total annual wage bill to the total *employed* human capital stock (Arrow et al., 2007). This, however, is not found to be practical for the case of Ethiopia for two main reasons. First, the data for total wage bill for Ethiopia is not available. Second, had it been available, total wage bill cannot be representative of total compensation for labourers as self-employment and employment in informal sectors are commonplace. A possible remedy is taking the share of labour in GDP as a crude proxy for total compensation of labour (Ollivier and Giraud, 2009). Studies based on Cobb-Douglas production function, estimate share of *paid* labour in GDP to be greater than or equal to 50% in Organization for Economic Cooperation and Development (OECD) and Asian; nearly 50% in Latin American; and Middle East and about 30% in Sub-Saharan economies (Lubker, 2007). Glyn (2008), on the other hand, shows an average compensation of labour (adjusting for self-employment) in 17 OECD countries was more than 65% of GDP. Taken together, taking about 60% of real GDP as the share of labour (both paid and unpaid) is reasonable for poor countries such as Ethiopia. Dividing this 60% of real GDP by total human capital stock yields annual rental value (w) of a unit of human capital. To put human capital as a function of education and health only we take the average w in survey period.

In strict sense, the calculation of m depends on age distribution of the population, the age specific mortality rate, and labour participation rate (probability of employment). Assuming both age specific mortality and labour participation rate remained constant in the period; we can obtain m for the *average age* of working population. The average age of working population based on the life expectancy in 1990 was 25 to 30 (WHO, 2010). The average remaining years of working were, then, calculated from the World Health Organization (WHO) Life Tables (WHO, 2010). The WHO Life Table report, however, is available only for the years 1990, 2000, and 2008. Same m was taken for each six years (i.e.1990 to 1995; 1996 to 2002; and 2003 to 2008) to fill the data gap. Referring the World Bank (2006) which estimates discount rate to be to be 2 to 4 percent in industrialized countries, a social discount rate of 5% is taken for Ethiopia. The annual investment in human capital (iHK_t) is then obtained by:

$$iHK_t = P_{ht} * (H_t - H_{t-1}) \quad \text{……………………………………………………………} \quad (10)$$

Because our survey period starts from the year 1990, the investment on human capital is calculated for the years onwards 1991. Column 3 of Table 3 gives the human capital investment in Ethiopia from 1990 to 2008. With crude assumptions on returns to education, social discount rate, the share of labour in real GDP, and data on labour force, educational attainment and life expectancy, human capital investment in Ethiopia was tracking the fluctuations in real GDP. While its average share (in the real GDP) was about 42% in the period, its share reached to 70% in 2003. The share, however, is continuously falling since 2004. By implication, the relative share of human capital and physical capital investment go in opposite direction: when the share of one goes up the other's share will go down.

Rents from the depletion of forests and minerals

As in the World Bank's approach, the rents from the depletion of forest and minerals are computed as in Equation 11 given below:

$$R_{it} = (P_{it} - AC_{it}) * E_{it} \quad \text{……………………………………………………} \quad (11)$$

Where, P= resource price, AC = average extraction or harvest cost, and E= volume of extraction for minerals and harvest beyond natural regeneration for forests. Because Ethiopia is not fossil fuel producer, it is only depletions of forests and minerals considered here. The *minerals* included in the World Bank estimates are bauxite, copper, iron, lead, nickel, zinc, phosphate, tin, gold and silver. The rents of forest depletion are based on timber prices and we hope the reader is aware of the fact that all minerals mentioned in the Bank's report are not fully explored in Ethiopia. Presuming the average cost of extracting minerals and logging forests annually grows at the same rate with price, hence, unit rents changing at the same rate as price, we can adjust the prices of other years at 2000 price (World Commodity Price, 2000=100, World Bank, 2009). The sum of rents from the depletions of forests and minerals, iNKt:

$$iNK_t = \sum_i^n Rit \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Colum 4 in Table 3 presents the rents due to forest and mineral depletion valued at international price for the period 1990 to 2008. As shown in the indicated column, the rents from forest and minerals depletion were immense. The category constitutes, on average, about 9% of real GDP in the period 1990-2008. The rents from both natural resources are especially, increasing after 2003, in absolute term. The share in the real GDP, however, starts to fall after the same year implying that the real GDP has grown faster than the rents of depletion post-2003.

Damages due to global carbon emission (or climate change)

Global warming and climate change, which mainly is driven by anthropogenic greenhouse gases emission, is imposing formidable environmental, economic, and social impacts in the world particularly on developing countries. Therefore, its impacts should be accounted. The global carbon emission is obtained from Eco-Economy Indicators in the Earth Policy Institute Website. The marginal social cost of US$50 per ton of carbon as in Tol (2005) was considered. Under a conservative climate change scenario (only 2.5^0C warming), the economic impact of climate change on African countries is estimated to be 3.91 % of their annual real GDP and 1.5% of world real GDP (Nordhaus and Boyer, 2000). Some studies on the impacts of climate change on agricultural productivity of some selected African nations, however, found that the Ethiopian agriculture to be less affected compared to other sample countries like Niger and Burkina Faso (Maddison , Manely, and Kurukulasuriya, 2007; Kurukulasuriya and Mendelsohn, 2008). The Federal Ministry of Finance and Economic Development (MoFED, 2010), on its part, estimated the economic impacts of climate change on Ethiopian economy to be somewhere between 2% and 6% of its GDP. In balance, 3% of real GDP is considered here as damage due to climate change. The damage due carbon emission to Ethiopia at time *t* (DEt) is then calculated as follows:

$$DE_t = DS_{it} * D_{wt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where, DE_t =damage due to global carbon emission on Ethiopia at time *t*; DS_{it}= the share of climate change damage to Ethiopia (3% of its real GDP each year) in the global damage owing to the same (1.5% of its world real GDP each year); D_{wt} (which is equal to \$50xE_{wct}) is the world social damage owing to carbon emission at time *t.*

The damages due to global carbon emission in Ethiopia, on average, account about 2% of its real GDP as presented in Column 5 of Table 3. The damage, moreover, is increasing both in absolute magnitude and share in real GDP. The increasing carbon emission (and hence increasing world damage due to climate change) along with increasing share of Ethiopian GDP in the world GDP is the main factor for the trend of the damage.

Damages due to particulate matters

The damage due to particulate matters (PM_{10}) is the very recently added variable in the comprehensive wealth accounting. Particulate matters are typical air pollutants. The WHO standard tells that particulate matters up to the thickness of ten micrometers are harmful to human health. The estimation of damages owing to PM_{10} is as follows:

$$DPM_{10}=DALY\ (\text{due to } PM_{10})*WTP \qquad (14)$$

Where DALY is Disability Adjusted Life Years to the morbidity and mortality of particulate matters and WTP is residents' willingness to pay to avoid mortality and morbidity attributable to particulate matters. As PM_{10} is local pollutant GDP deflator is used to adjust to real variable. The share of the damages due to PM10, as shown in Column 6 of Table 3, was hovering around 1%.

Comprehensive investment

Comprehensive investment (CI), then, is the sum of net investments in physical capital, human capital, natural capital, and damages due to environmental externalities (I_i) valued at their respective shadow prices (q_i).

$$CI = \sum q_i I_i \qquad (15)$$

Comprehensive wealth growth rates

The Harrod-Domar economic growth model shows that economic growth is positively associated with saving rate (the ratio of national saving to national output) but inversely related with incremental capital output ratio (ICOR). Treating the economy as closed, where there is no/little import and export, it is assumed that capital accumulation (or investment) is financed by domestic savings. Extending the same model implies that comprehensive investment equals comprehensive savings. Then, the comprehensive wealth growth rate (g_{CW}) is:

$$g_{CW} = \frac{\left(\frac{CI}{RGDP}\right)}{ICOR^*} \qquad (16)$$

Where RGDP is real GDP and ICOR* is *adjusted* incremental capital output ratio. Because the conventional measures of investment or saving rates (and hence economic growth rates) do not include natural and human capital investments, and adjusted ICOR (ICOR*) is commonly obtained by adding arbitrarily one on the conventional ICOR (Kumar and Managi, 2009).

Adjusting for changes in exogenous factors

Among other exogenous effects, the effects of population and technological (and institutional) changes are widely considered in the economics literature. Due to unavailability of data on total factor productivity growth (a proxy variable to technological change) and lack of studies to infer from, we considered only the effects of population growth rate here. Our final *per capita comprehensive wealth growth rate*, therefore, will be:

$$g_{cw}=g_{CW} - gPop \qquad (17)$$

Where, g_{cw} = per capita growth rate of comprehensive wealth and gPop=population growth rate. Table 4 summarises the per capita growth rates under different scenarios in Ethiopia (1990-2008). The per capita comprehensive wealth growth rate under scenario 1 (gcw1) incorporates the human capital investment while gcw2 (per capita comprehensive wealth growth rate under Scenario 2 omits the later. The conventional per capita real GDP growth rate was taken as a baseline scenario. As shown in the table, the per capita growth rates under all scenarios have been increasing especially after the year 2004. One can claim the average growth rates under all scenarios were not satisfactory. Not only was the comprehensive wealth growth rates low (0.55% under Scenario 1 and -1% under Scenario 2 but also too low compared to the per capita real GDP growth rate (2.22%).

DISCUSSIONS

Macroeconomic Performance of Ethiopia (1990-2009)

Table 1 depicts the basic macroeconomic data of Ethiopia from 1990 to 2009. As shown in the table, the macroeconomic performance of Ethiopia was dominated by negative figures in the early 1990s. The average real GDP growth rate was only 2.88% from 1990 to 2003. The negative economic growth rates of the fiscal year 1998 and 2003 may, respectively, owe to the border conflict with Eritrea and drought. The Ethiopian economy, however, is scoring a promising high economic growth rate in the last seven consecutive years. The average of real GDP growth rate from 2004 to 2009 was 11.2%.

But, is this double-digit real GDP growth rate strong enough to overwhelm the depletion in different natural resources (forests, minerals, and land degradation) and be resilient to both local (e.g. water and air pollution) and global (e.g. carbon emission and the resulting climate change)? This is the main research question of this paper. The subsequent sections discuss the question.

Ethiopian Economy and Sustainability: A comprehensive wealth accounting

Economists use comprehensive wealth accounting to measure inter-temporal welfare of a given society and its change (*i.e.* comprehensive investment) to show the sustainability of the same economy. We used four ways to assess the sustainability of Ethiopian economy in 1990-2008. We will consider each in turn in the subsequent subsections to follow.

Comprehensive investment

The first step to assess the sustainability of a given economy is to compute the comprehensive (genuine or inclusive) investment at each point of time as shown in Equation 5. The weak (the economic or capital) rule of sustainability, then, requires the comprehensive investment to be greater than zero at each point of time. Under Scenario 1 (CIR_1, see Column 7 in Table 3) Ethiopia has met the criterion of sustainability in each year. However, under Scenario 2 (CIR_2, see Column 8 in Table 3) the nation failed to meet the criterion in 1992. This implies that the change in physical capital was overwhelmed by the rents in forest and minerals' depletion and damages due to particulate matters and carbon emission in the same year. The inability of the physical capital investment, of course, is confirmed by the negative real GDP growth rates -7.14% and -8.67%, respectively in 1991 and in 1992. The other point is that the growth of CIR_2 is too slow compared to the growth of CIR_1. This shows the role of human capital is critical in sustainable development. Figure 1 in the Appendix clearly depicts this argument.

Per capita growth rates under different scenarios (1990-2008)

Growth rates are usually used to assess economic performance overtime. Calculating the growth rates under alternative scenarios help to see a form of capital that contributes more to the sustainability. In other words, it helps to see to what extent gross physical capital formation and economic growth rates are different from the genuine investment and comprehensive wealth growth rates.

Figure 2 depicts the per capita growth rates of comprehensive wealth (under both scenarios) against the traditional per capita growth rate of real GDP for the period 1990 to 2008. As one would expect, the growth rate under Scenario1 is the highest, except for the first three years of the survey period in which it was negative due to the simultaneous fall in the net physical capital and human capital investments. This shows that the contribution of human capital investment in shaping the sustainability of the Ethiopian economy was critical. Of course, the average share of human capital formation was two times (42% of real GDP) the net investment of physical capital (20% of real GDP). Another important lesson to be drawn from Figure 2 is that the growth rate under Scenario1 tracks the growth rate under Scenario3. This implies that the growth in the comprehensive wealth is primarily driven by the growth in net physical investment as human capital investment changes very slowly.

The share of different capital investments/disinvestments (% real GDP)

Depicting the share of different capital investments in the real GDP help us to see what contributes more to comprehensive wealth creation and what influences more to the trajectory of comprehensive wealth growth. As shown in Figure 3, the share of human capital investment was relatively high as well as volatile component. In addition to this, the share of human capital investment was also changing as the average remaining years of working (*i.e.* **m**) increases (from 37 to 37.4 in 1996; and from 37.4 to 40 in 2003). Partly, the fluctuation in the share of human capital is due to the fluctuation in the share of physical capital investment. As the two investments constitute more than sixty percent of real GDP each year, the fall in the share of one implies the increase in the other. While the share of damages due to the two environmental externalities remains relatively stable from 1990 to 2008 the relative share of net physical investment was slowly increasing especially after 2000.

Comprehensive Investment versus Gross Investment

The other and perhaps the easiest way to compare the sustainability of a given economy overtime is to compare the conventional (gross) physical capital ratio to real GDP (GIR) and the ratio of comprehensive investment to real GDP under Scenario 2 (CIR_2). This gives a clear picture on how the country is progressing (conventionally) without considering the environmental costs of the growth. Such depiction, especially, is very important for environmental economists and environmental policy makers. Figure 4 depicts the difference more clearly. Needless to say, there is visible gap between the gross investment ratio and comprehensive investment ratio under Scenario 2 albeit the trajectory is the same.

The vertical distance between the two curves represents the sum of depletion of forests and mineral resources and damages owing to climate change and air pollution. The gap was almost intact throughout the period. This implies, as also shown in Figure 3, the share of the three negative components of comprehensive (*i.e.* depletion of forest and mineral resources; damages due to carbon; and damages due to particulate matters) was almost stable in the survey period.

Therefore, the country either should work more to reduce pressure on natural capital; to increase its financial, technical, and institutional capacity to cope up with environmental externalities; or to grow fast to compensate these detrimental factors.

CONCLUSION

The traditional measures of human welfare narrowly consider only physical capital as source of national income while a nation's productive base consists of natural capital and human capital in addition to physical (or manufactured) capital. A nation's productive base, however, is affected by variations in different capital assets and some other exogenous factors (such as population and technological changes). Add to this, the conventional (or neo-classical) measure of human welfare also measures the environment inconsistently. Not only conventional measures omit the value of the environment to economic activities but also record income earned through depletion of the environment and expenditure meant to maintain the environment as gain.

Therefore, economists and policy makers suggested a better (and wider) measure of national wellbeing. To this effect, the notion of sustainable development emerged as a guiding principle of economic growth and development in the mid 1970s. Sustainable development requires human welfare measures to consider as large as possible social, cultural, demographic, technological, environmental, economic, and political aspects which do affect the present and the future well-being of the society. The issue of sustainable development is especially important in developing countries where natural capital contributes more than physical capital and rapid population growth is imposing pressure on the natural resources.

This paper has attempted to give a picture on the sustainability of Ethiopian economy, a typical developing country in the sub-Saharan region, using the method of comprehensive wealth accounting. Three alternative scenarios – per capita comprehensive wealth growth rate *with* and *without* human capital investment and the per capita growth of real GDP – were constructed. All growth rates were positive and increasing after the year 2004. On average, however, the growth rates were respectively 0.55%, -1% and 2.3% under Scenario 1, Scenario 2, and baseline scenario. In most of the years (except the years of political transitions and instability, *i.e.*, the first three years of the survey period; some exogenous shocks due to border conflict in 1998, and drought in 2003) the growth rate under Scenario 1 was higher. This implies that the role of human capital investment in determining sustainability of a given economy.

The paper has tried to draw important lessons for policy implications. Ethiopia has alternative ways to adjust its economic growth in line with the requirements of sustainable development. It can reduce the pressure on the natural resources through stringent environmental policies and regulations. Alternatively, it should grow fast enough to overwhelm the disinvestments in natural assets. Ethiopia should also build up both technical and financial adaptive capacity to cope up with damages owing to global and local environmental externalities. Last is to devise ways to check its fast growing population.

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APPENDIX: TABLES AND FIGURES

Table 1: Basic macroeconomic data of Ethiopia (1990-2009)

Year	Nominal GDP	Real GDP	GDP Defl.	gRDP
1990	12,08,25,76,935.27	6,23,36,82,737.96	1.94	2.73
1991	13,36,14,46,739.17	5,78,87,66,562.71	2.31	-7.14
1992	14,09,80,12,280.75	5,28,67,19,782.13	2.67	-8.67
1993	8,76,35,57,094.07	5,98,15,44,745.49	1.47	13.14
1994	6,87,51,70,145.31	6,17,23,68,103.04	1.11	3.19
1995	7,60,56,74,115.75	6,55,05,80,456.50	1.16	6.13
1996	8,48,28,83,272.62	7,36,45,50,132.93	1.15	12.43
1997	8,89,08,26,692.79	7,59,53,59,797.54	1.17	3.13
1998	8,06,94,37,010.95	7,33,26,97,406.73	1.10	-3.46
1999	7,82,70,68,144.67	7,71,12,40,982.39	1.02	5.16
2000	8,17,95,33,779.17	8,17,95,33,779.17	1.00	6.07
2001	8,16,85,90,426.73	8,85,85,52,228.85	0.92	8.30
2002	7,78,95,48,644.40	8,99,27,34,182.83	0.87	1.51
2003	8,53,87,69,774.14	8,79,83,93,779.77	0.97	-2.16
2004	10,03,43,68,538.43	9,99,25,43,571.78	1.00	13.57
2005	12,28,56,35,746.81	11,17,35,46,750.44	1.10	11.82
2006	15,13,37,52,486.04	12,38,41,59,131.25	1.22	10.83
2007	19,18,22,83,493.76	13,80,28,90,302.18	1.39	11.46
2008	25,89,92,16,445.82	15,29,05,93,236.98	1.69	10.78
2009	28,52,62,77,751.18	16,62,34,00,731.98	1.72	8.72

Source: World Development Indicators (2009)

Table 2: Basic population data of Ethiopia (1990-2008)

Year	Working Pop.	gPop
1990	26212095	2.9
1991	27039137	4
1992	27846738	2.2
1993	28424696	2.1
1994	29091734	2.5
1995	29968774	3
1996	30966458	2.8
1997	31944432	2.8
1998	32941059	2.9
1999	33925325	3
2000	34896758	3
2001	35949153	3
2002	37095281	3.1
2003	38282299	3.2
2004	39505744	3.2
2005	40759270	3.2
2006	42030189	3.2
2007	43305095	3.2
2008	44604911	3.2

Source: US Census (website)

Table 3: Investments in different capital assets in Ethiopia

Year [1]	iPK(+) [2]	iHK (+) [3]	iNK (-) [4]	dC(-) [5]	dPM_{10}(-) [6]	CI_1 [7=2+3-4-5-6]	CI_2 [8=2-4-5-6]
1990	1223026465	-	742020140	157872804	59331069.7	-	263802451.7
1991	962060937	2619446506	715145883	146520790	83154971	2636685799	17239293
1992	721142223	2632493388	740959475	128627112	103020221	2381028803	-251464585
1993	901938335	2157480870	518378980	143135429	36523344.7	2361381451	203900581.1
1994	1130423959	2411522077	571292526	145709306	21975544.9	2802968659	391446582.1
1995	1211807748	2962021398	785655865	153602423	25760356	3208810503	246789104.5
1996	1180248211	3204726627	714869883	170609387	28369804.6	3471125764	266399136.6
1997	1568201576	2990339504	698790103	172921914	29416524.5	3657412539	667073034.5
1998	1586931736	3080474316	882328576	162613169	24648617.8	3597815689	517341373.2
1999	1649296734	3095804232	723364758	164055702	21624636.9	3836055869	740251637.1
2000	1575843981	3109749795	734914151	171111068	21819272.1	3757749285	647999489.9
2001	1744834932	3562668925	874283854	186777834	20284399.9	4226157769	663488844.1
2002	1963842274	3866378047	779841336	187452099	18247206.7	4844679679	978301632
2003	1776497292	6250589715	895701036	187207513	20385004.9	6923793453	673203738.4
2004	2200590463	4307209050	965477633	214984159	23308480.3	5304029241	996820190.8
2005	2233770268	4467747083	891177422	241171182	29297577.7	5539871169	1072124086
2006	2643660864	4538527895	837087507	265173835	37347385	6042580032	1504052137
2007	3342607374	4629691216	916879100	289211096	50896548.2	6715311846	2085620630
2008	3287986861	4780112846	1023741010	320961627	82854986.3	6640542084	1860429238

Source: Adjusted Net Savings, World Development Indicators (2009); US Census, IDB (website); Barro-Lee (website); Earth Policy (website)

Table 4: Growth rates under different scenarios (1990-2008)

Year	CIR_1	CIR_2	ICOR*	gCW_1	gCW_2	gPop	gcw_1	gcw_2	$gGDP_{pc}$
1990	-	0.04	8.57	-	0.49	2.9	-	-2.41	-0.17
1991	0.46	0.00	-1.45	-31.39	-0.20	4	-35.39	-4.21	-11.14
1992	0.45	-0.05	-0.66	-68.70	7.25	2.2	-70.90	5.06	-10.87
1993	0.39	0.03	2.21	17.88	1.54	2.1	15.78	-0.56	11.04
1994	0.45	0.06	7.04	6.45	0.90	2.5	3.95	-1.60	0.69
1995	0.49	0.04	4.18	11.72	0.90	3	8.72	-2.10	3.13
1996	0.47	0.04	2.36	19.99	1.53	2.8	17.19	-1.27	9.63
1997	0.48	0.09	7.93	6.07	1.10	2.8	3.27	-1.69	0.33
1998	0.49	0.07	-5.59	-8.78	-1.26	2.9	-11.68	-4.16	-6.36
1999	0.50	0.10	5.36	9.28	1.79	3	6.28	-1.21	2.16
2000	0.46	0.08	4.34	10.59	1.82	3	7.59	-1.17	3.07
2001	0.48	0.07	3.50	13.64	2.14	3	10.64	-0.86	5.30
2002	0.54	0.11	16.18	3.33	0.67	3.1	0.23	-2.43	-1.59
2003	0.79	0.08	-8.83	-8.91	-0.86	3.2	-12.11	-4.07	-5.36
2004	0.53	0.10	2.71	19.60	3.68	3.2	16.40	0.48	10.37
2005	0.50	0.10	2.78	17.83	3.45	3.2	14.63	0.25	8.62
2006	0.49	0.12	3.07	15.87	3.95	3.2	12.67	0.75	7.63
2007	0.49	0.15	3.23	15.09	4.68	3.2	11.89	1.49	8.26
2008	0.43	0.12	3.10	14.01	3.92	3.2	10.81	0.72	7.58
Average	**0.49**	**0.07**	**3.16**	**3.53**	**1.97**	**2.97**	**0.55**	**-0.99**	**2.23**

Source: Based on Table 1-3 above.

Figure 1: The trends of comprehensive investments in Ethiopia (1990-2008)

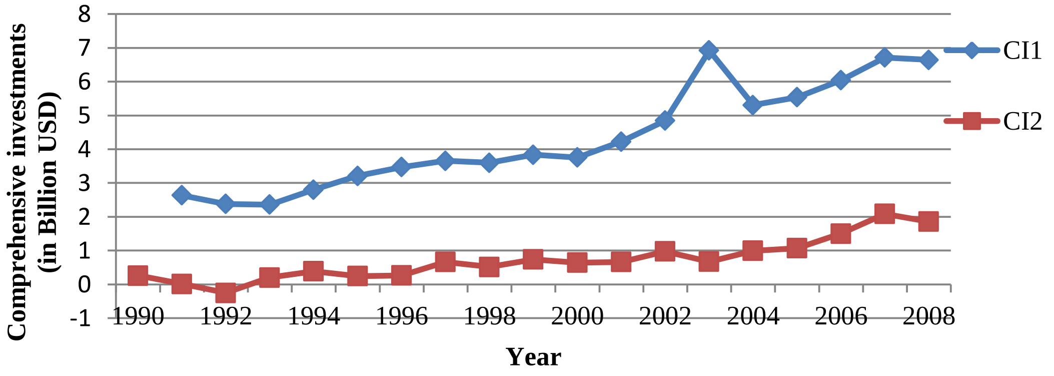


Figure 2: Per capita growth rates of Ethiopia in different scenarios (1990-2008)

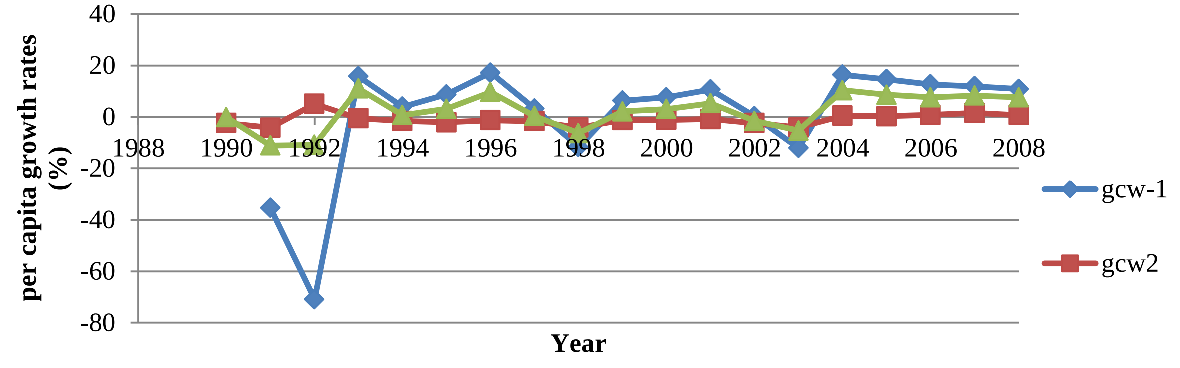


Figure 3: The share of investments/disinvestments in real GDP (1990-2008)

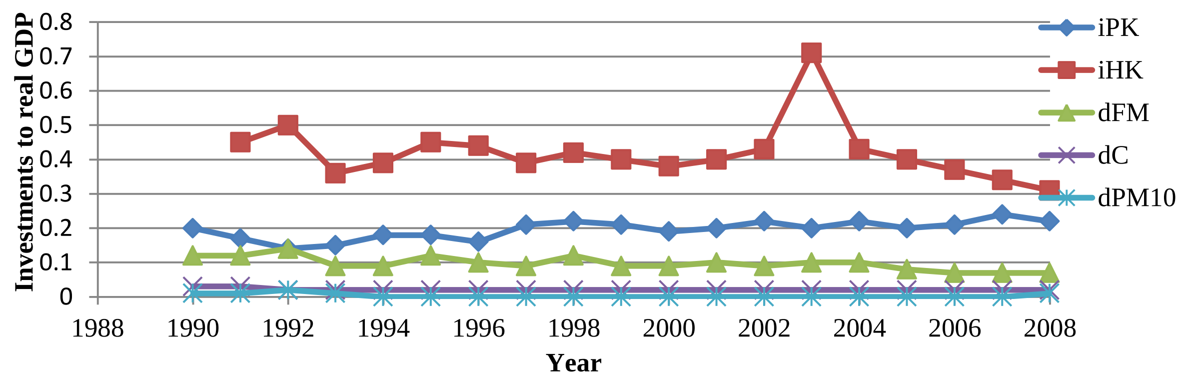
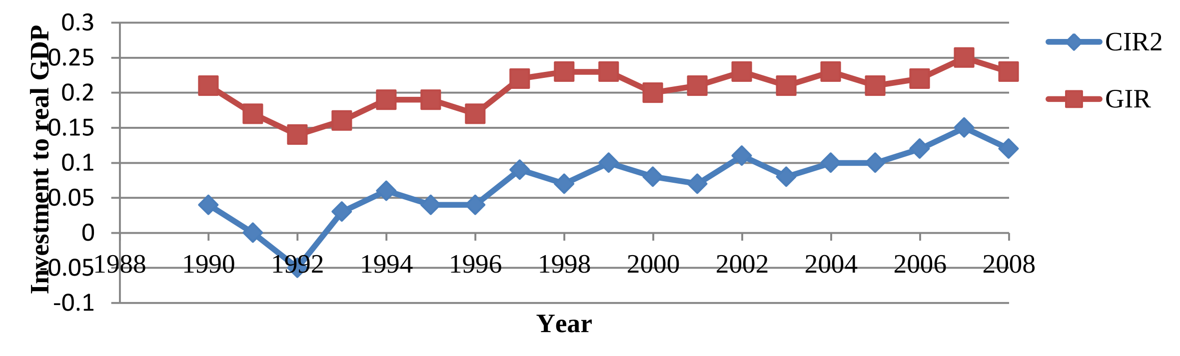


Figure 4: Comprehensive Vs gross investment ratios (1990-2008)



APPENDIX: POLITICAL MAP OF ETHIOPIA

Source: Retrieved February 6, 2013 from Vidiani.com Maps of the World: http://www.vidiani.com/?p=8410