Journal of
Environmental and Social Sciences

Open Science Publications

Volume 3, Issue 2 - 2016

www.opensciencepublications.com

Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development

Research Article

Asghedom Ghebremichael*

Research Economist, The Environment and Natural Resources, Department of Natural Resources, Government of Canada, 5320-122 Street, Edmonton, AB, Canada

***Corresponding author:** Asghedom Ghebremichael, Research Economist, the Environment and Natural Resources, Dept. of Natural Resources, Government of Canada, 5320-122 Street, Edmonton, AB, Canada T6H 3S5, tel.: 1+780-435-7298, fax: 1+780-435-7359, E-mail: global.gsnet@shaw.ca or asghedom.ghebremichael@canada.ca

Article Information: Submission: 06/07/2016; Accepted: 06/09/2016; Published: 10/09/2016

Abstract

The neoliberal doctrine of perpetual economic growth (PEG), often referred to as sustainable economic growth, is disputed critically. Genuine sustainable development (GSD) is advanced as the best alternative. PEG means unfettered expansion of an economy's productive capacity under laissez-faire to boost gross domestic product (GDP) at an inevitable risk of breaching "planetary boundaries". Laissez-faire is a neoliberal free-market economic doctrine that promotes activities of multinational corporations to free-ride in the marketplace, enabled by their respective governments' institutions. By contrast, GSD is a dynamic process by which human well-being is improved in an inclusive, a just, and an environmentally safe operating space. It can be achieved through inventions, innovations, diffusion, and adoption of appropriate technologies as well as learning-by-doing. Key features that characterize the competitive general equilibrium model of neoclassical microeconomic theory are highlighted to show the incompatibility of PEG with GSD. Diagrams, selected bioecological growth functions and basic microeconomic models are used to demonstrate that human well-being depends mainly on effective political governance system, ecological integrity, biodiversity, ecological carrying capacity, and the life sustaining multiple services of ecosystems. The consequences of destroying natural capital assets are explained; and a call is made for anthropogenic balancing act not to transgress ecological thresholds. The fact that the biosphere is an embodiment of all life on Earth and of the world's material wealth is reiterated; selected pathways to GSD are summarized; and specific policy measures required to curtail excessive anthropocentric activities are proposed.

Keywords: Ecological integrity; Ecological carrying capacity; Ecological thresholds; Ecosystem services; Institutional configurations; Perpetual economic growth; Genuine sustainable development; Effective political governance system

Introduction

The biosphere is a self-regulating natural system of the global ecosystems. It embodies all living beings and their relationships among themselves and with the elements of the other three major spheres: lithosphere (rocky), geosphere (geologic), hydrosphere (water), and atmosphere (a layer of gases of nitrogen 78.09%, oxygen 20.95%, argon 0.93%, and 0.039% CO_2) [1]. Dynamically created and sustained through exchanges, transfers, and connections of energy, materials, and information, the biosphere is a life-sustaining system of the Earth. Through the collective metabolic activities of its innumerable plants, animals, and microbes physically and chemically, the biosphere unites the atmosphere, geosphere, and hydrosphere into one environmental system within which millions of species, including humans, have thrived. Breathable air, potable water, fertile soils, productive lands, bountiful seas, the healthful climate of Earth's recent history, and other ecosystem services are manifestations of the workings of a healthy biosphere.

The biosphere embodies *natural technology* for which there is no substitute and on which human survival depends. Health, integrity, and sustainability of the biosphere and its ecosystems cannot be taken for granted. "The awe and wonder it generates continues to inspire every human being that takes the time to behold and ponder it; it is a great gift-a gift given and yet not owned by all who receive it. This gift is also a giver of gifts; it gives life through a myriad of provisions" [2].

Nature has its own set of rules, solidly grounded in laws of physics and chemistry, and emergent principles of geology and biology, which are not artificial constructs. The natural rules are real, and they govern human well-being. Earthquakes, tsunamis, volcanic eruptions, hurricanes, tornadoes, floods, droughts, famines, civil conflicts, wildfires, poverty, and disease epidemics demonstrate dramatically that our planet Earth is at risk. Moreover, the outbreak of novel diseases, such as Ebola and AIDS, in socially, economically, and ecologically impoverished regions is a clear signal of the global predicaments of inequality and poverty. These natural and anthropogenic disasters are clear indicators of ecological overshoot, meaning anthropogenic disturbances beyond the carrying capacity of ecosystems that lead to ecological crash, causing an *eventual die-off*, hence environmental disasters [3]. The frequency, scale, and adverse effects of these challenges must be of great concern to humanity.

"Human alteration of the Earth was substantial and growing, transforming between one-third and one-half of the global land surface; CO_2 concentration in the atmosphere increased by nearly 30% since the beginning of the Industrial Revolution; more atmospheric nitrogen was fixed by humanity than by all natural terrestrial sources combined; humanity consumed more than half of all accessible surface-freshwater; and about one-quarter of the bird species on Earth were driven to extinction" [4]. The UN's Millennium Ecosystem Assessment [5], a global landmark study, which involved more than 1,360 scientists, technical experts, and policy makers from around the globe, summarized its findings as follows (paraphrased): (i) although living standards of "the few" have improved over the past two centuries, human activity is putting such strain on nature, undermining the Earth's capacity to support current and future generations; (ii) we are living beyond our means: the current gains in enhanced quality of life have come at a considerable cost to health and integrity of ecosystems on which human well-being depends; (iii) if we act now, we can avoid irreversible damage to ecosystems and to our well-being; and (iv) we can no longer treat Nature's bounty as free and limitless.

The information summarized in Table 1(*Ecological Foundations* section below) makes it all clear that human well-being depends on the life sustaining multiple services of ecosystems. Furthermore, a team of renowned scientists from N. America, Europe, Australia and the Scandinavian countries identified the following nine ecological thresholds, which define "the safe operating space for humanity": (i) climate change, (ii) rate of terrestrial and marine biodiversity loss, (iii) human interference with the natural cycles of nitrogen and phosphorus, (iv) stratospheric ozone depletion, (v) ocean acidification, (vi) global freshwater consumption rate, (vii) land-use-change, (viii) chemical pollution, and (ix) atmospheric aerosol loading. The team concluded that humanity was *approaching* to the boundaries for *freshwater consumption, land-use-change, ocean acidification*, and *interference with the global phosphorus cycle*, while the boundaries for *climate change, biodiversity loss*, and *interference with the nitrogen cycle* have already been *transgressed* [6]. An urgent call for an anthropogenic balancing act not to transgress ecological thresholds is in order. Halting short-sighted excessive anthropocentric activities that lead to overexploitation of natural resources is imperative. The naturally imposed limiting frontiers, the ecological thresholds, must be respected and protected.

Rooted in the doctrine of *laissez-faire*, neoliberalism promotes perpetual economic growth (PEG), which means unfettered expansion of an economy's productive capacity realized through enabling institutional arrangements. But, PEG is inherently not compatible with ecological integrity, environmental quality, and genuine sustainable development (GSD). Drawing on the findings , conclusions, and recommendations of Rockström's team [6], I define GSD as a dynamic process by which human well-being is improved in an inclusive, a just, and an environmentally safe operating space, achieved through inventions, innovations, diffusion, and adoption of *appropriate technologies* as well as *learning-by-doing*.

GSD is in a stark contrast with the highly publicized and politicized concept of *sustainable development* (SD) of the UN's Brundtland Commission, which is also known as World Commission on Environment and Development (WCED) (1987) [7]. The highly generalized and vague definition of SD is: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: (1) the concept of "needs", in particular the essential needs of the world's poor, to which overwhelming priority should be given; and (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs". *Our Common Future*, p.143.

Given all its good intentions, the WECD failed to explain the consequences of PEG strongly. Unfortunately, SD's exact definition continues to be globally politicized and linked always to strategic policy goals and objectives one would like to talk about. SD does not give any specific guidelines pertinent to alleviation of the human predicaments associated with inequality, poverty, perversely globalized markets, destruction of the health and integrity of ecosystems, and climate change.

Research questions, goal, and organization of the paper

What are the theoretical and practical foundations of the PEG doctrine? Are PEG and GSD compatible? Addressing these questions has become a persistent challenge to both social and natural scientists. The overarching goal of this article is to demonstrate the incompatibility of PEG with GSD.

Rooted in neoclassical microeconomic theory, neoliberalism advocates for PEG, which is unfettered expansion of an economy's

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

productive capacity in the finite, materially closed (except the constant inflow of solar energy), and non-growing biosphere [8]. For this doctrine to be realized, neoliberal economists prescribe globalized perfectly competitive markets, where multinational corporations play the dominant economic games against all policies and strategic practices of GSD.

Let me be clear at the outset. As a trained economist, who went through the grueling processes of acquiring a PhD, I understand the importance of all the fundamentals of microeconomic and macroeconomic theories. My argument is against the misuse and, in some case, abuse of these scientific theories to promote personal ideological perceptions. I am motivated to add my "voice" to those voices of many preeminent scholars, whose extensively published works inspired me to learn more on the adverse effects of neoliberalism on ecological integrity and human well-being [6, 8-12].

The paper is organized into six sections: this introduction, ecological foundations for GSD, the fallacies of the PEG doctrine, anthropogenic effects on ecological integrity, selected pathways to GSD, and concluding remarks and policy recommendations, in that order.

Ecological Foundations of Genuine Sustainable Development

In this section, I summarize the ecological foundations of GSD, using taxonomy of the following key scientific terms: ecological principles of holism, biodiversity loss, sustainability, resilience, ecological integrity, biogeochemical processes, carrying capacity, and overshoot.

Principles of holism

Ecological principles of holism mean that everything is interconnected with everything. This can be summarized by the dictum: "A whole is more than the sum of its parts or members". The totality of the whole of any living system-biological, social, or economic-is not fully embodied in its individual parts or members. *Wholes* have properties that are not present in any of their separate parts; they emerge only when the parts are combined together, forming mutually reinforcing synergistic nexus, in a coherent whole; and the specific properties of individual parts disappear when they are part of the whole.

Thus, relationships among the parts of wholes matter; when relationships change, the whole is changed. For example, water, air, and soil are polluted with chemical and biological waste, because we humans fail to appreciate the importance of their holistic relationship with Nature and thereby with our well-being. Respiratory problems, cancer, food poisoning, and general poor health as well as the cost of healthcare are some of the consequences of ignoring the imperatives of *holism*.

Government policies that influence agriculture, forestry, mining, manufacturing, labor relations, capital investments, employment, economic growth, all have direct and indirect impacts on the natural environment-locally, nationally, and globally. We have no way of knowing how large or small our individual or collective adverse effects may be, but understanding the ecological principles of holism is necessary condition to preserve ecological integrity and foster human well-being.

Consequences of biodiversity loss

Biodiversity (i.e., biological diversity) is the number, variety and variability of genes, populations, species, communities, ecosystems, and ecological processes. Biodiversity underpins the multiple services of ecosystems that sustain human well-being; is the foundation of resilience of life on Earth; and an integral part of the fabric of all the world's cultures. It is a common knowledge of the science of ecology that no feature of Earth is more complex, dynamic, and varied than the layer of organisms that occupy its surfaces and its seas; and no feature is experiencing more dramatic changes at the hands of humans than this extraordinary, singularly unique and beautiful feature of the Earth, biodiversity. Critical ecological processes (i.e., ecosystem functions) that depend on prevailing scale of biodiversity at the ecosystem level influence plant productivity, soil fertility, water quality, atmospheric chemistry, and many other local and global environmental conditions that ultimately affect human welfare.

Substantial changes have already occurred, especially local and global losses of biodiversity. The primary cause has been widespread human transformation of once highly diverse natural ecosystems into relatively species-poor managed ecosystems. Recent studies suggest that such reductions in biodiversity can alter both the magnitude and the stability of ecosystem processes, especially when biodiversity is reduced to the low levels typical of many managed natural systems. We humans ought to remind ourselves that barren deserts are capable of supporting very little life (if any), because they lack biological diversity. Ecosystems that completely lack diversity have no high quality, *low entropy*, energy left to support life.

Diversity enables living systems to adapt and evolve to accommodate their ever-changing natural environment. Even if we do not understand fully the specific nature of a threat, it should be clear that loss of biodiversity represents a growing threat to the future of human life on Earth. There is no way of knowing how many more species can be lost before the ecological balance is tipped toward extinction of all species.

Sustainability

What does this revered-modern term, *sustainability*, mean? It means the capacity to endure natural and/or human-induced adversities and remain in existence. Ecologically, it is how biological systems remain diverse and productive in perpetuity. Long-lived and healthy wetlands and forest ecosystems are examples of sustainable biological systems. In more general terms, sustainability is the endurance of systems and processes.

For the purpose of this paper, the unifying concept I have chosen for the science of sustainability is GSD. It is a process by which human well-being is improved in an inclusive, a just, and an environmentally safe operating space, achieved through inventions, innovations, diffusion, and adoption of *appropriate technologies* as well as *learning-by-doing*. In other words, GSD integrates five domains: social, ecological, economic, environmental, and institutional. However, despite its importance, the possibilities that human societies will achieve GSD is getting harder and harder with time, because of environmental degradation, climate change, overproduction, overconsumption, rapid growth of the human population, and the pursuit multinational corporations for PEG at any cost, through full

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

support of *neoliberalism's institutions* that create a globalized-free market economy.

Thus, it is imperative to direct orientation of human behavior toward planetary endurance and sustainability over time. This behavioral orientation provokes reflection on the manner and purposes of global human society. Problems like biodiversity loss and climate change point to the global reach of humanity's powers and the scale of its risk. Mitigating their impact and risk require reform across many human systems-financial, political, production, consumption, energy, transportation, and even communication and education. Yet those reforms could complicate other goals of the international community, such as overcoming extreme poverty and protecting human rights. How can these overlapping interests be prioritized? At local and global levels, sustainability directs practical attention to the complex mutuality of human and ecological systems. Economic health, ecological integrity, social justice, and responsibility to the future must be integrated to address multiple global problems within a coherent, durable, and moral social vision. That inclusive scope and prospective vision makes sustainability ideologically absorptive and socially and politically viable.

Resilience and resistance

An ecosystem's *resilience* refers to its ability to recover from disturbances (e.g., wildfires, diseases, insect infestations, climatic extremes, overgrazing, and overexploitation of natural resources) that exceed its *resistance* capacity. *Resistance* is the capacity of an ecosystem to tolerate and mitigate disturbances. Linked to sustainability, *resilience* in ecology is the capacity of an ecosystem to absorb disturbance and still retain its basic structure, functions, and viability.

Resilience-thinking evolved from the need to manage interactions between human-constructed systems and natural ecosystems in a sustainable way, despite the fact that the definition remains elusive to policymakers. Resilience-thinking addresses how much planetary ecological systems can withstand assault from human disturbances and still deliver the services current and future generations need from them. It is also concerned with commitment from geopolitical policymakers to promote and manage essential planetary ecological resources in order to promote resilience and achieve sustainability of these essential resources. Resiliency of an ecosystem, and thereby, its sustainability, can be reasonably measured at junctures or events where the combination of naturally occurring regenerative forces (solar energy, water, soil, atmosphere, vegetation, and biomass) interact with the energy released into the ecosystem from disturbances.

Integrity

An ecosystem is an assemblage of organisms (biotic) interacting among themselves and the physical environment (abiotic), including air, light, soils, heat, and water, at a specific location. Ecological integrity encompasses attributes of a healthy ecosystem, which include: abundance of biodiversity, resistance and resilience, sustainability, naturalness, wilderness, beauty, wholeness, and natural-maximum carrying capacity. Integrity of an ecosystem is manifested through its self-sustaining intact natural processes; it evolves naturally; its capacity for self-renewal is maintained; the biodiversity is ensured; and is free of human and natural disturbances. Using these and other attributes, ecologists develop indexes that capture current condition of a given ecosystem.

Biogeochemical processes in ecosystems

Biogeochemical processes in ecosystems are referred to ecosystem functions. These are ecological processes that control the fluxes of solar energy, nutrients, water, and organic matter throughout of a given natural environment. Examples include: (a) primary production, the process by which plants use solar energy to convert matter into new biological tissues through photosynthetic chemical reactions; (b) nutrient cycling, the process by which biologically essential nutrients are captured, used, released, and then recaptured; and (c) decomposition, the process by which organic waste, such as dead plants and animals, is broken-down, assimilated, and recycled. These functions are controlled by both the diversity and identity of the plant, animal, and microbial species living within a given community of living things. Human modifications to the living community in an ecosystem as well as to the collective biodiversity of the Earth can, therefore, alter ecological functions and sustainable supply of the life sustaining multiple services of ecosystems (Table 1).

Life sustaining multiple services of ecosystems

What are ecosystem services? They are *fluxes* of services and the *stocks* that they (the fluxes) produce for all living things to enjoy and survive (Table 1).

Sustainable supply of these life sustaining services is a function of ecological integrity. The lack of a universally accepted single definition implies diversity of the services, ecological complexity, and degree of their importance for humanity. Development of human societies has been a story of changing the natural systems of planet Earth to sustain ever more sophisticated and excessively comfortable ways of living. "Human activities have taken the planet to the edge of a massive wave of species extinction, further threatening our own well-being" [5].

Carrying capacity and overshoot

Ecologists define *ecological carrying capacity* as the maximum population of a given species that a particular ecosystem can support in perpetuity [13]. For the purposes of this article, the concept of *carrying capacity* is defined as the maximum level of human population size and its anthropogenic activities that a particular ecosystem can sustain under existing technologies, institutional configurations, demographic structure, and governance system. *Overshoot*, in contrast, is a condition where human population size and its anthropogenic activities have exceeded the carrying capacity of a given ecosystem [3]. In this situation, the ecosystem does not have the capacity to regenerate life-sustaining services or to absorb, detoxify, or neutralize wastes of economic growth. The theoretical and practical perspectives of ecological carrying capacity are elaborated in the fourth section, diagrammatically and mathematically, after the next section on the fallacies of the PEG doctrine.

Fallacies of the Neoliberal Doctrine of Perpetual Economic Growth

The previous sections have established the ecological foundations for GSD on which more elaborations will follow this section.

Table 1: The four functional classes of ecosystems and their respective services.

Supporting Services	Provisioning Services	Regulating Services		Enriching-Cultural Services
♦ Soil formation ♦ Photosynthesis ♦ Primary production (production of biomass of animals, plants, and microorganisms) ♦ Soil nutrients and water cycling ♦ Biodiversity maintenance ♦ Decomposition of waste and dead organic matter	♦ Food crops ♦ Freshwater ♦ Fish ♦ Livestock, game ♦ Wildlife habitat ♦ Wood fiber ♦ Nontimber forest products (e.g., mushrooms, honey, berries, nuts) ♦ Genetic resources ♦ Biochemicals, natural medicines, etc. ♦ Ornamental resources ♦ Fuelwood ♦ Ecotourism business ventures	♦ Moderating extreme climatic conditions ♦ Purifying air and water ♦ Conserving soil and water ♦ Sequestering CO_2 ♦ Detoxifying and decomposing wastes ♦ Dispersing seeds ♦ Mitigating impacts of drought and floods ♦ Protecting stream and river channels and coastal shores from erosion	♦ Protecting people from the sun's harmful ultraviolet rays ♦ Maintaining biodiversity and ecosystem integrity ♦ Contributing to climatic stability ♦ Regulating disease-carrying organisms ♦ Pollinating food crops and natural vegetation ♦ Protecting channels, dams, and rivers from being silted up ♦ Contributing to biological pest control	♦ Cultural diversity ♦ Inspirational ♦ Educational ♦ Sense of place ♦ Cultural heritage ♦ Scientific knowledge ♦ Aesthetic ♦ Spiritual and religious ♦ Recreation ♦ Social relations ♦ Therapeutics (the healing power of Nature)

Incompatibilities of the perpetual economic growth (PEG) doctrine with health and integrity of the biosphere and with the conditions necessary for GSD are explored here. The following features of neoclassical microeconomic theory, the mother of neoliberalism, are elaborated: (a) the economy as an open subsystem of the biosphere, (b) the limitations of the competitive general equilibrium model of microeconomic theory, (c) the causes and consequences of the functional failures of the competitive market structure, (d) the unrealistic nature of the assumed conditions where the neoclassical economic model of *laissez-faire* market economy is expected to work, and (e) the wrong metrics of human well-being.

The economy as an open subsystem of the biosphere

To argue for PEG, neoliberal economists invoke the theoretical fundamentals of neoclassical macroeconomic models. That is, PEG promotes growth of gross domestic product (GDP) through an unfettered expansion of an economy's productive capacity within the biosphere, which is finite, non-growing, materially closed (except for the constant input of solar energy), and constrained by the laws of thermodynamics (Figure 1). Note that a closed system is one in which matter neither enters nor exits, but energy enters as low entropy (high quality) and exits as high entropy (low quality). It is this *throughput* of energy that powers the material biogeochemical cycles on which life depends [8-9].

An economy is a socially constructed and legally and politically mediated an open subsystem within the biosphere (Figure 1). To be sustainable, it must be designed, organized, and function as a societal living system in accordance with the ecological and social paradigm of *interconnectedness* of living organisms. Sustainability of life on Earth depends on the inflow of solar energy; and only living organisms are capable of capturing, organizing, concentrating, and storing solar energy in diverse forms necessary to support life on Earth.

Low entropy (high quality) solar energy and materials, along with generated energy and human capitaland information embedded in machinery, equipment, and information and communication technologies, flow from the biosphere through the open economic subsystem (Figure 1). Subsequent to all socioeconomic activities, high entropy, i.e., degraded and dissipating energy and waste material that pollute the natural environment flow back to the biosphere. It might be possible to minimize the magnitude of pollution, if effective policy for recovering, reusing, and recycling (3Rs) is implemented. But, as the *Second Law of Thermodynamics* (aka *Entropy Law*) teaches us, most of the degraded material and energy dissipates as waste during the economic processes irrevocably [9].

Observe Figure 1 The sustainable level of energy throughput is a function of the biosphere to sequester low entropy (useful) solar energy and the capacity of the natural environment to absorb, detoxify, or neutralize wastes. Unsustainable economic growth, the PEG, can be compared to growth of a malignant cancer, because it devours its own support system, the Earth's ecosystem services (Table 1). Like an animal does, the economy lives on devouring all low entropy (useful energy contents) natural capital assets, such as fish, timber, arable land, water, metals and minerals, and fossil fuels, given back waste materials. This outcome, of course, diminishes the *productive, regenerative, absorptive, decompositive*, and *assimilative capacities* of the biosphere. Many fear that unless overexploitation of natural resources is checked, modern civilization will follow the path of ancient civilizations that collapsed because they overexploited their natural resources [3,9].

A bit more elaboration on the physics of the *First* and the *Second* laws of thermodynamics is warranted. According to the *First Law of Thermodynamics*, also referred to as the *Law of Energy/Material Conservation*, material inputs to economic processes are not "consumed", because they return as wastes to the natural environment from where they were extracted. This means that, during a physical or chemical change, energy is neither created nor destroyed, although it may change from one form to another; and it may move from one place to another. When one form of energy is converted to another form in any physical or chemical change process, energy input equals energy output- we cannot get something for nothing is the dictum.

By contrast, the *Second Law of Thermodynamics* states that with each change in a form of energy some energy is degraded to a less useful form and given off to the surroundings, usually as low quality heat. That is, in the process of performing work, *low entropy* energy is converted into *high entropy*, which is waste energy characterized by

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

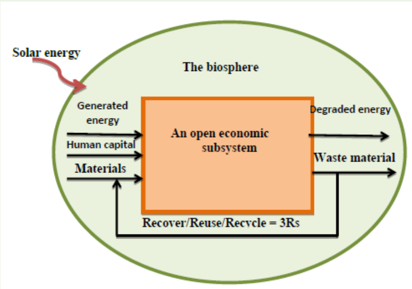

Figure 1: An open economic subsystem in the biosphere.

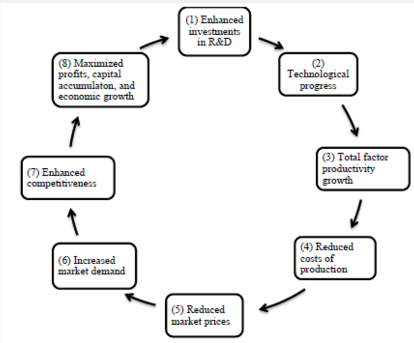

Figure 2: Hypothetical virtuous cycle of enhanced investments in R&D under the neoclassical economic growth doctrine.

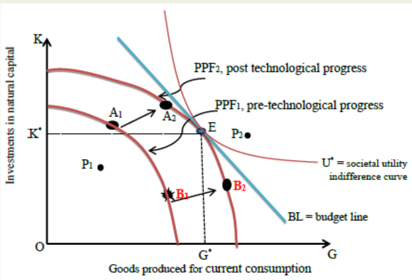

Figure 3: Competitive general equilibrium in exchange, consumption, and production.

dispersed, dissipated, and molecularly chaotic state. This is an index of irrevocably dissipated energy [9].

Economic implications of the *Second Law*, however, are far subtle and are very important. Economic processes utilize low entropy energy and raw materials (e.g., fossil fuels and high grade metal ores) and discard high entropy wastes. This process imposes constraints on economic growth. That is, anthropocentric economic processes transform valuable (low entropy) matter and energy into irrevocable waste. For example, when coal is burned to generate electricity, only about 35% of the total energy embedded in the coal is converted into electrical energy, the rest becoming waste heat, various gases (e.g., CO_2), various chemicals, such as sulfuric acid, particulates, and ash; and even the electricity dissipates into the natural environment as waste heat once it has done its job [14]. The physicist may argue that the "books are balanced" - there is just as much matter and energy in the overall system as before in accordance with the *First Law of Thermodynamics*. But, the *Second Law* refutes *The First*: whatever remains is very significantly lower in quality. The upshot is that for every unit of good product that a human being creates, using a given technology, he manufactures two units of bad product - and even usefulness of the good product is ephemeral [14]. In short, the idea that technology will allow us to do ever more with ever less in perpetuity is a delusion.

Keep in mind, there is always diminishing returns to happiness. Naturally, under the constraints of the biosphere the *Law of Diminishing Returns* dictates that once the basic human needs, such as food, clothing, shelter, health, education, and clean water are met quality of life becomes dependent more on social capital and on one's general purpose of life than on additional material wealth. That is, the materialistic doctrine of PEG does not enhance happiness in life.

Unravelling limitations of the competitive general equilibrium model

The theoretical foundations of the neoclassical competitive general equilibrium model of microeconomics are examined here. For the sake of clarity, I start with a virtuous cycle framework for positive feedback to illustrate the intricacies of the economic growth paradigm, which advances the PEG doctrine (Figure 2). *Positive feedback*, also referred to as *cumulative causation*, is a *loop system* in which the system responds to a perturbation, such as financial stimulus within the economic system.

For example, let us assume that exogenously designed, enabling macroeconomic policies, such as: reduced corporate income tax, increased corporate investment credits, reduced royalties to extract a given natural resource (e.g., fish, timber, oil, or gas), and enabling institutional configurations and coordination, motivate corporations to enhance investments in R&D (Stage 1). This leads to technological progress through inventions, innovations, diffusion, and adoption of new technologies (Stage 2). Then, the following sequence sets in: total factor productivity growth (Stage 3), reduced costs of production (Stage 4), competitively reduced market prices (Stage 5), boosted market demand for goods and services (Stage 6), enhanced competitiveness (Stage 7), and maximized profits, accumulated capital, enhanced investments, and economic growth (Stage 8), pushing forward the original conditions (Stage 1) to enhanced economic climate through positive feedback effects. These sequences push the *production possibilities frontier* (PPF), also referred to as *transformation possibilities frontier*, outwards (Figure 3).

Because human *desires* and *wants*, which are both unlimited, exceed our *basic needs* due to *scarcity*, trade-off decisions must be made in production, consumption, and investment under given technology, factors of production, preferences and tastes, expectations, and institutional configurations. Effective and efficient allocation of scarce resources is possible only along the PPF of the economy in question (Figure 3). Neither investment in natural capital nor production of current consumption goods is viable at points, such as P_1, where *inefficiency* prevails, and point P_2, where both investment and production are *unattainable*. Possibilities for optimality in production of current consumption goods and investments in sustainable

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

management of natural capital can be attained at points, such as point E, on PPF_2, after technological progress.

Take, example, point E as a point that establishes optimality, where slope of PPF_2 can be expressed as a negative value:

$$-\frac{dK}{dG} = MRT_{GK} \quad (1)$$

where MRT_{GK} is marginal rate of transformation of G (production of current consumption goods) for K (investments in natural capital). This is a measure of the rate at which investments in K have to be given up to get an additional unit of G. It is interpreted as an *opportunity cost*, a relative marginal cost of G in terms of given up amount of K. That is,

$$MOC_{GK} = \frac{MC_G}{MC_K} = MRT_{GK} \quad (2)$$

where: MOC_{GK} = marginal opportunity cost of the benefits gained from G in terms of K; MC_G = marginal cost of G in consumption; MC_K = marginal cost of K in production; and MRT_{GK} is as defined above, under Equation (1).

In a freely competitive market economy, profit maximizing firms produce at output level where marginal cost (MC) is equal to the ratio of *product prices*; and consumers, who maximize utility, purchase goods and services by equating their marginal rates of substitution (MRS) to the ratio of *product prices*. At point E (Figure 3), the competitive general equilibrium in production, exchange, and consumption is established, expressed as:

$$\frac{MC_G}{MC_K} = \frac{P_G}{P_K} = MRS_{GK} = MRT_{GK} \quad (3)$$

where: P_G = price of a given product for current consumption; and P_K = price of a given natural capital asset for future consumption (e.g., timber to be harvested through sustainable forest ecosystem management); and MRS_{GK} = marginal rate of substitution of product G for product K in consumption.

Close observation of the situations in Figure 3 reveals that, if society chooses to invest at point A_2, post technological progress, future generation will enjoy the benefits of reduced current production of consumer goods; but, if society chooses to give up investing in natural capital by choosing $B_2$to produce more current consumption goods, future generations will be *worse-off*, because their opportunities to enjoy the benefits of ecosystem services are depleted, while current generation will be *better-off*.

Furthermore, one has to keep in mind the potential for unintended consequences of the positive feedback outcomes (cumulatively increasing causations) of technological progress as elaborated in Figure 2. There exists likelihood for excessive positive feedbacks to encounter negative feedbacks that can throw a system out of its equilibrium position (point E, Figure 3) into a chaotic transformation. To complicate matters further, the neoclassical economic model is expected to work under presumed very stringent assumptions, which are summarized as follows:

Assumed necessary conditions for a perfectly competitive market structure

Neoclassical welfare economic theory asserts that the market mechanism is an effective device for allocating scarce resources through the Adam Smith's "invisible hand" maxim, which allegedly creates demand and supply equilibrium, mediated by *rational behaviors* of economic agents of production and consumption, who are profit and utility maximizers, respectively.

The so called perfectly competitive market structure is assumed to function under the following stringent conditions: (i) a national government, relegated to the duties of macroeconomic stabilization, protection of economic and political freedoms and private property rights and leaving the domestic marketplace wide open for competition in order to foster free market economic globalization; (ii) government ownership of productive sectors of the economy results in market distortions, hence not permitted; (iii) in a free-market economy, economic agents possess complete knowledge of the marketplace, i.e., no information *asymmetry* exists; (iv) rational producers and consumers, maximizing profits and utilities, respectively, allocate scarce resources effectively and efficiently; (v) positive or negative externalities are ruled out; (vi) firms are free to either enter or exit industries; (vii) collusive strategies of producers to create *oligopolies* and/or *monopolies* to erect market barriers that enable them to earn *supernormal profits* (net earnings that exceed all opportunity costs) compared to *normal profits* (minimum net earnings that cover opportunity costs to induce the firm to remain in operation) are not expected to exist; (viii) numerous producers and consumers of a given product operate in the marketplace, where neither of them is capable to influence workings of the demand and supply market forces; (ix)individual persons, firms, and households are price takers, i.e., neither has power to influence market prices; (x) homogeneous technologies produce homogeneous products (e.g., fish, oil, gas, lumber, paper, computers, guns, etc.) for the marketplace; and (xi) human ingenuity creates national wealth in perpetuity, through inventions, innovations, diffusion, and adoption as well as learning-by-doing of new technologies.

Relying on these unrealistic assumptions, neoclassical economics, the mother of *neoliberalism*, neglects the adverse effects of risk and uncertainties on the workings of a given economy; and of large scale production, distribution, exchange, consumption of market commodities on quality of the natural environment, i.e., human well-being. Most importantly, the inevitable *failure* of the so called competitive mWWarket and the predicaments of *inequality* are not the concern of neoliberalism [16].

Governed by these preconditions, neoclassical economic growth models are constructed and applied to generate empirical results used for policy making. It is very disquieting to understand that some of the economists who adhere to the intricacies of the neoclassical economic growth model sare winners of the *Nobel Prize for Economic Sciences* [18,20,21].

For good or for worse, depending where one stands ideologically, these economists, revered by their disciples, influenced economic and political spheres of many developed and developing countries over the 20th century. For instance, Milton Friedman [21], who won the *Nobel Prize for Economic Sciences* in 1976, when he was a *guru* of neoliberal economic theory at the Chicago University School of Economics, was an advisor to the Chilean dictator, General Augusto Pinochet [22]. In his book, *Capitalism and Freedom*, which is extensively read

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

and translated into several languages, Fried man asserts that, under perfectly market competitive capitalism, free-innate human nature determines economic outcomes, which are necessary conditions for political freedom, and thereby well-being of humanity. This is the *crux* of the true neoliberalism, which Milton Friedman prescribed for General Augusto Pinochet's Chile (1973-1990), an era of *the Chilean tragedy* [22].

Keep in mind that the norms of neoliberalism are privatization, deregulation, and liberalization of national economies by implementing enabling institutions that establish a freely competitive marketplace, where multinational corporations play the dominant economic games. Notice, reviewing the above highlighted assumed necessary conditions should be enough to convince ourselves that the so called perfectly competitive market structure is an *absolute abstraction* that cannot exist under any circumstances. In the real world we live in an ideal-perfectly competitive market structure that benefits all members of a society cannot exist.

A caveat on the limitations of technological progress is also in order here. No doubt, technological progress, revealed through an outward shift of the PPF and *total factor productivity* growth, reduces costs; increases productive efficiency; conserves on the use of scarce-productive factors, including natural resources, human capital, and produced capital; and, hence, contributes to human well-being. But, the *Second Law of Thermodynamics* forbids perpetual technological progress; and it is subject to the constraints of diminishing returns, i.e., an additional input quantity of a productive factor, *ceteris paribus*, results in a marginal increase in output up to a certain point, beyond which diminishing returns, measured in terms of declining marginal productivity, set in. Furthermore, all technological transformations cause energy and matter to be *degraded* and *dissipated*.

Why and how *laissez-faire* market economy fails

Markets are socially constructed spatial organizations, managed in accordance with established national institutions. In effect, a national government has obligations to create level playing field in the social, economic, environmental, and political spheres. For example, institutions pertaining with private, communal, and public *property rights* ought to be well detailed and delineated for an effective political governance to prevail. Moreover, a government of the day is expected to design and effectively enforce implementation of environmental quality protection policy instruments.

I use the following few examples to sketch the inevitable failures of the so called perfectly competitive market to allocate society's scarce resources effectively and efficiently:

- *Monopolies and oligopolies*: Collusively established monopolistic and oligopolistic corporations that erect barriers to entry reap *supernormal profits*.
- *Imbalance of market power*: Asymmetry of information, meaning one economic agent possessing information on the market another agent does not possess, creates imbalance of market power.
- *Public goods*: The market does not have a place in allocating *public goods*, which are *non rival* in consumption (open for everyone to use) and *non-excludable* in sharing benefits (impossible to exclude others from sharing in the benefits of goods and services). For example, mitigation of the adverse effects of climate change, vaccination against an epidemic, clean air from the natural environment, and provision of national security are *pure public goods*, the social benefits of which cannot be captured by the market place's price mechanism.
- *Imperfection of the labor market*: The prevalence of unemployment, demonstrating labor supply exceeding demand at prevailing wage rates, reveals the imperfections of the labor market in the corporate world.
- *Frequent economic crises*: Neoclassical macroeconomic policies of neoliberalism, which advocate for free and openly globalized competitive markets, are often doomed to failure. Frequent financial meltdowns (e.g., the 2007-2008 crisis), recessions, depressions, which are often accompanied by massive unemployment, are symptomatic of pervasive market failures.
- *Anthropogenic-adverse-environmental externalities*: These are adverse effects of one economic agent's activities (production, consumption, or combination of both) on another agent's economic activities or livelihoods in general. Generally, one of three conditions or their combination makes environmental externalities (positive or negative) intractable: (a) potential interdependence between economic agents, (b) lack of or weak property rights, and (c) the prohibitive nature of *transaction costs*. A chemical factory's spillage of contaminated water into a waterway system is a good example. Along the waterway system (rivers and lakes) communities of people live carrying out their economic activities: gardening, farming, fishing, etc. Obviously, the human health and livelihood costs of the pollution should enormously be high. The so called freely competitive market does not capture such social costs (refer Table 1). The *marginal social costs* are far greater than the *marginal private costs*. The industry *externalizes* (passes on to society) these social costs. If the industry is able to compensate the communities, however, we can say the costs were *internalized*. But, this will be expensive for a profit maximizing industry, which contributes to the national economy in one way or another. So, there is a catch that calls for a mediating political power, government, because the free market mechanism does not have a place. This is the reason why many countries have environmental protection agencies (EPAs), which are directly answerable to their governments. From the guidelines and the research literature it publishes, the EPA of the United States is a very good model. It implements a portfolio of policy instruments from: the command and control, the market-based, the zoning, and the public awareness (education) instruments.
- *Transaction costs*: In any social, economic, and governance interactions, transaction costs are incurred. They include all sorts of cost items, such as: market research, bargaining, monitoring, evaluating, enforcing, contractual agreements,

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

defining and assigning property rights, brokerage commissions, etc. Clearly, all these and similar costs require enforceable institutions (detailed in the 5th section: Selected Pathways to GSD). In such a socioeconomic and governance complexity, expecting neoliberalism to work for the well-being of all citizens is a folly. All of the necessary conditions for the perfectly competitive market will inevitably be violated, leading to a massive market failure, with a potential consequence of financial crisis. What follows *financial meltdown* is often an *economic meltdown*, revealed through rising unemployment and/or underemployment, companies going out of business, wages and benefits dropping or stagnating, rising inflation, declining gross domestic product (GDP), and declining investments. Then, governments of the free market economies are often compelled to use tax payers' money to *bailout* corporations, with no guarantee that a *vicious cycle* will not ensue.

The wrong metric of human well-being

Consciously or unconsciously, governments use GDP as an economic growth yardstick, linking it to human well-being. But, GDP is just an aggregate estimate of monetary transactions, computed either from output value added, incomes, or expenditures of an industrialized economy. For the peasant economies, which account for about 80% to 90% of the poor nations' hand-to-mouth incomes, GDP does not "add up".

The following Keynesian *national income accounts identity* (NIAI) of an open economy illustrates the meaning of GDP:

$$GDP \equiv Y \equiv C + I + G + (X - M) = C + I + G + NX \quad (4)$$

where: C = household consumption expenditures; I = gross-private investments; G = public (government) expenditures; NX = net export earnings (gross export earnings, X, minus imports, M).

Hence, GDP is just a gross tally of products and services bought and sold, with no distinctions between transactions that enhance human well-being and those that diminish it. It does not distinguish between *social costs* and *social benefits*, productive activities from destructive activities, or sustainable ones from unsustainable ones; it simply assumes that every monetary transaction adds to human well-being (Table 2).

Moreover, GDP growth has associated costs that outweigh the benefits. Simon Kuznets, the architect of GDP, is often quoted clarifying that GDP "was not meant as the primary scorecard of a nation's economic health and well-being". Unfortunately, economists, governments, international agencies, such as the World Bank and the International Monetary Fund, NGOs, and the media, use GDP as the primary measure of a nation's economic health and human well-being. This is despite the fact that needless expenditures triggered by crime, accidents, toxic waste contamination, preventable natural disasters, prison expenditures, and corporate fraud count the same as socially desirable productive investments in housing, education, healthcare, sanitation, or mass transportation are part of the GDP accounting system.

Most importantly, the non-tradeable multiple services of ecosystems (Table 1) are not accounted for in the GDP system. Multinational corporations, operating under the rules of neoliberalism, *externalize* (pass on to the public) social costs and ecological damages associated with their operations.

In a seminal book, *Mismeasuring Our Lives: Why GDP Doesn't Add Up*, two Nobel Laureates in the *Science of Economics*, Joseph E Stiglitz and Amartya Sen, and the renowned French economist, Jean-Paul Fitoussi [12], stressed that human well-being must mean *availability*, *accessibility*, and *sustainability* of the following (paraphrased) conditions for all citizens:

- Essentials of life: food, shelter, clothing, safe drinking water, energy, monetary income, livelihood materialassets, health, and education
- Personal involvement in productive work and leisure activities
- Universal suffrage for an effective political good governance system (detailed in the 5th section)
- Social connections and relationships, i.e., strong social capital
- Best quality of social and natural environments to live in
- Constitutionally enshrined and enforced rule of law to ensure *primacy of the rule of law*
- Ability to enjoy all the flows and the stocks of the services of ecosystems
- Capacity to cope with and to mitigate the adverse effects of natural and human-induced disasters (e.g., drought, famine, civil conflicts)

In short, financial transactions, such as GDP growth, are wrong metrics of human well-being.

Anthropogenic effects on ecological carrying capacity

Table 2: Some social costs and benefits that invalidate GDP as a metric of human well-being.

Social costs	Social benefits
• Natural resource depletion • Depreciation of all human-made capital assets, including infrastructures, machinery, and equipment • The predicaments of inequality • Loss of ecosystem services • Biodiversity loss(productive, regenerative, absorptive, and assimilative capacities of the natural environment) • Environmental degradation • Ozone depletion • Family breakdowns • Crimes • Congestions • Pollution abatements • Healthcare • Soil erosion • Loss of wetlands • Air and water pollution	• The nonmarket values of the multiple services of ecosystems (refer columns 1, 3, and 4 of Table 1) • Homemaking of mothers and other family members • Volunteer services • Possibly much more

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

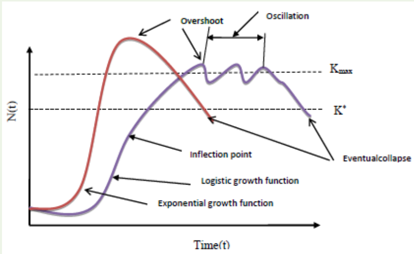

Figure 4: Exponential and logistic growth functions, depicting ecological overshoot, oscillation, and collapse. *N* = human population size and intensity of anthropocentric activities, *t* = time; K_{max} = maximum carrying capacity; K* = optimum carrying capacity.
Source: Adapted from Barrett and Odum (2000) and Sterman (2000).

Sound knowledge of ecological carrying capacity is a prerequisite to develop a coherent and viable policy for sustainable ecosystem management, and thereby for GSD. Healthy marine and terrestrial ecosystems are embodiments of natural capital assets that determine GSD. While the meaning of carrying capacity is detailed previously in the second section, the adverse effects of unfettered economic growth on ecological carrying capacity and human well-being are demonstrated in this section.

Capacities of the natural environment

As highlighted in the introductory section, the global economy has physically grown to such a size that it now exceeds the *productive* and *regenerative* as well as waste *absorption*, *decomposition*, and *assimilation* capacities of the Earth's ecosystems, i.e., we are in ecological overshoot, resulting in a *crash* [3,13]. When anthropocentric activities exceed these five types of the natural environment's capacities, the maximum carrying capacity, K_{max}, is bound to collapse (Figure 4). The ideal situation is to reach and maintain the optimum carrying capacity, K^*. Figure 4 depictWs the well-known growth functions of exponential and logistic, each exhibiting (in its own way) the potentially adverse impacts of human population and intensity of anthropocentric activities on the carrying capacity of an ecosystem. That is, accounting for anthropogenic effects on ecological integrity involves consideration of both human population size and per capita demand for natural capital assets. The inverse relationship between material wealth and ecological integrity is an important fact that must be kept in mind [13]. Because of the diverse applications of these two empirical functions and their importance for policy making, each function is described briefly as follows:

The exponential growth function

The exponential growth function (Figure 4) can be expressed as:

$$N(t) = N(0)e^{rt} \tag{5}$$

where: $N(t)$ = human population size and the degree of its activities' intensity at time t, $N(0)$ = initial human population size and socioeconomic conditions at t = 0, e = natural logarithmic base, and r = a given population's growth rate. This model is based on the assumption of an unlimited supply of natural capital. Although it is conventionally used to describe population growth in accordance with the Malthusian tradition, it is used here to illustrate the adverse effects of excessive anthropogenic activities on ecological integrity, causing human-induced overshoot and an eventual collapse (Figure 4).

The logistic growth function

With a long history of empirically proven efficacy, the logistic growth function is a useful illustration of biological and physical modes of growth [23]. It is expressed as a differential equation with respect to time, t:

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K^*}\right) \tag{6}$$

where: r = intrinsic biological growth rate, N = population size at time t, and K^* = optimum carrying capacity of the ecosystem.

It was in 1838 that Verhulst, a French mathematician, discovered this growth function, which replaced Malthus's theory of exponential growth of the human population and arithmetic progression of food production [24]. In 1920, two American biometricians, Pearl and Reed, proved it correct; and in 1925, another American researcher, Lotka, formally derived the equation, calling it the law of population growth [25].

In a logistic growth curve, inflection points are points where the curve switches from an increasing growth rate to a decreasing rate (or vice versa). The *oscillating mode* of change in relation to K_{max} reveals interactions among tightly coupled elements of biological, social, economic, and environmental systems (Figure 4). These systems are continuously bombarded by human-induced perturbations, leading to irregular combinations of endogenous dynamics and exogenous perturbation shocks [23]. As the *draw-down* (i.e., extraction) of natural capital intensifies, however, the ecosystem's carrying capacity is approached, the adequacy of the life-sustaining ecosystem services is overshot, and, eventually, the system collapses (Figure 4).

Although local terrestrial and marine ecosystems are open to intake of solar energy, they must be considered as subsystems of a much larger planetary system that is finite, non-growing, and materially closed. As the productive capacity of an economy expands, the carrying capacities of the terrestrial and marine ecosystems become *limiting factors* that impede unfettered expansion of an economy's productive capacity.

As anthropogenic activities increase to boost GDP growth, the structure, composition, resilience, functions, and carrying capacity of ecosystems are bound to be altered abruptly. Because of feedback loops, the abrupt changes in stocks and flows of the services of ecosystems occur, compounded by nonlinear interactions among the natural, physical, institutional structures and the decision-making agents acting within it. The oscillating section of the logistic growth function reveals this inevitable outcome [23].

Thus, GSD will remain elusive so long as the ecological damages and social costs of expanding the productive capacity of economies are *externalized* and disproportionately borne by those who benefit the least. In effect, the final outcomes are the predicaments of inequality. Market price signals, which reflect the effects of policies, institutions, technologies, infrastructure, and human preferences, must be aligned with the objectives of GSD. This alignment should be realized with a clear understanding that the multiple services and the natural capital asset stocks that ecosystems generate determine human well-being.

Selected pathways to genuine sustainable development

As detailed in the introductory section, my working definition of GSD is a dynamic process by which human well-being is improved in an inclusive, a just, and an environmentally safe operating space. This is achievable through inventions, innovations, diffusion, and adoption of *appropriate technologies* as well as learning-by-doing. Compared to that definition of the WCED [7], discussed in the introductory section, GSD stresses living within the frontiers of the biosphere, where the natural *productive* and *regenerative* as well as waste *absorption, decomposition*, and *assimilation* capacities of ecosystems are preserved. To trigger more future research and dialogue, I have selected the following pathways to GSD:

Social capital as a unifying democratic asset: Rooted in a society's commonly shared cultural attributes of language, values, norms, mores, faith, customs, and roles (sets of leadership abilities) social capital is a socially constructed asset that fosters mutually beneficial collective actions. In other words, it unites all members of a given social fabric to enhance mutual benefits; and it can also be considered as a collectively owned wealth.

Social capital is manifested through the following social characteristics: mutual trust and tolerance, shared cultural values and norms, spirit of cooperation and reciprocity, social networks, political and civic engagements, sense of communal life style, adherence to common rules and sanctions in accordance with collectively sanctioned institutions that configure formal and informal rules, roles played by trusted members, and collective voices and actions for mutual gains.

Ceteris paribus, communities blessed with high stocks of social capital are: safer, cleaner, wealthier, more literate, better governed, and generally ``happier'' than those without or with low stocks, because their members are capable: to commit themselves to each other's well-being; to feel a greater attachment to one's own social fabric; to build and maintain a culture of democracy; to create a welcoming and nurturing environment; to build adaptive capacity to adverse circumstances (e.g., climate change); to find and keep good jobs; to initiate projects that serve all members; to monitor one another's behavior without the burden of transaction costs; to enforce contractual agreements; to use scarce resources more effectively and efficiently; to resolve disputes more amicably; and to respond to members' concerns more promptly [26,27].

Adaptive co-governance: A new paradigm, rooted in deliberative-democratic principles, adaptive co-governance (ACG) is defined here as the organizational structure and processes by which stakeholders make decisions on sharing power, benefits, and costs through well designed institutional configurations that maintain order and conditions for collective actions. A dynamic at temporal and spatial scales, ACG is a set of best practices that evolve over time. It can be viewed as a *people's science*, because its outcomes are based on active participatory dialogues among all stakeholders. Moreover, socioecological and political systems are interlinked in continual adaptive cycles of diversification, growth, accumulation, and renewal. Because it is based on equal partnership, ACG has the power to unleash human potential for creative cooperation and to share productive resources and surpluses for the good of all members. Thus, science and public policy making can be balanced in sustainable ecosystem management decision making at the federal, provincial, territorial, municipal, and community levels.

ACG is expected to create conducive conditions that: (i) bridge organizational divide; (ii) foster social learning (experiential and experimental) to generate and mobilize human capital; (iii) advance mutual trust, norms, and shared values, which are collectively useful to build *social capital stock* for effective governance; (iv) reduce transaction costs, uncertainties, and risks; (v) promote collaborative-scientific research; and (vi) enable hinterland communities, whose social and economic infrastructures are not developed, to build adaptive capacity for coping with climatic, economic, and political shocks [28-30].

By virtue of its consensus-based institutional configurations and implementations, ACG is a governance system that is expected to adjust to changes in the structure, composition, functions, resilience, and carrying capacity of a given ecosystem (e.g., a forest or a watershed). In the absence of effective governance institutions, however, natural resources and the natural environment are bound to be in peril from increasing human population that causes economic activities (production, distribution, and consumption) to soar by deploying advanced technologies that devour natural resources. Thus, institutional, policy, and coordination failures must be avoided. The general process of consensus building to develop effective institutions for an effective ACG is illustrated in Figure 5.

Adaptive strategies that sustain the ability of ecosystems to support diversity of life, including human well-being, involve making tough decisions under uncertainty, complexity, and biophysical constraints and conflicting human needs, norms, and values; and thus, effective ACG can be designed, if the following ideal conditions are in place: (i) the natural resources and anthropogenic use of the resources can be monitored, and the information can be verified and understood at relatively low cost (e.g., credibility of forest inventory is relatively better than that of fish; and lakes are easier to monitor than rivers); (ii) rates of change in use of natural resources, the user population, technology, and economic and social conditions are moderate and

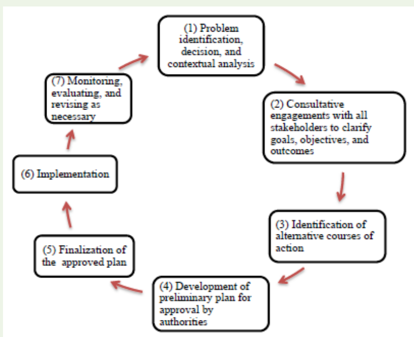

Figure 5: A general consensus building process to develop an adaptive co-governance strategy for sustainable management of ecosystems.

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

amenable to development; (iii) communities maintain frequent face-to-face dialogues and dense social networks-often referred to as social capital-that enhance the potential for trust, allow people to express and see emotional reactions to distrust, and reduce transaction costs of monitoring and regulating, inducing compliance to mutually beneficial rules; (iv) outsiders can be excluded effectively from using the resources (because new entrants add to the harvesting pressure and typically do not understand the existing rules of the community); and (v) all members, the stakeholders, support effective monitoring and enforcement of the rules.

The challenge is devising and implementing effective institutions that help to establish such ideal conditions through the process illustrated in Figure 5. This can be done, if there is full understanding that ACG enables stakeholders to develop capacity to perform ecosystem management, manage multiple ecosystem services, and monitor, communicate, and respond to ecosystem-wide changes at landscape and seascape levels with visible effects on natural capital. It has been demonstrated that government imposed policies, conflicts, demographic factors, ecological changes, and changes in livelihood options-among others-compel human communities to adopt ACG.

Human communities that are able to enhance their adaptive and governance capacities can easily deal with challenges, such as conflicts, make difficult trade-off decisions between short-and long-term well-being, and implement effective institutions for ecosystem management so that the capacity of a given ecosystem to generate the life sustaining multiple services is maintained. In short, ACG is an effective governance mechanism, because identifying and defining pertinent issues, designing courses of action, and monitoring and evaluating results are all carried out by all stakeholders collectively (Figure 5).

Traditional ecological knowledge: Traditional ecological knowledge (TEK) is a cumulative body of knowledge, consisting of traditions, moral values, norms, and religious beliefs handed down from one generation to another through cultural transmission mechanisms (e.g., interpretation of history, teaching, imitation, and storytelling), concerned with the relationship of humans with one another and with their natural environment. TEK can be a source of new ecological insights, make contributions to coherent policy, and play roles in formulating the principles of ACG.

Precautionary principles approach: Precautionary principles approach (PPA) is a risk management approach which has been developed for circumstances of uncertainty about credible scientific knowledge of a risk. It calls for prudence in the face of potentially serious risk, without awaiting completion of scientific research. It reminds all economic agents to "play it safe", because of the lack of scientific certainty about the adverse effects of economic activity on the natural environment.

PPA has four core guiding principles: (i) taking preventive action against risk in the face of uncertainty; (ii) shifting the burden of proof to the proponent of an activity; (iii) exploring a wide range of alternatives to potentially harmful actions; and (iv) increasing public participation in decision making [31]. PPA reiterates that absence of full scientific certainty shall not be used as an excuse to postpone precautionary decisions where there is a risk of serious or irreversible harm.

PPA is distinctive within science-based risk management, dictated by three basic tenets: the need for a decision, the risk of serious or irreversible harm, and the lack of full scientific certainty as to *what, when, where*, and *how* irreversible damage might occur.

Institutional framework

Meaning and functions

In a democratic governance system, institutions are socially and legally sanctioned and principled guidelines that specify goals, objectives, obligations, rights, rules, and decision-making procedures applied to maintain order of human interactions by: (a) prescribing human behavioral roles; (b) guiding human activities; and (c) shaping and directing expectations in order to meet needs and desires of all stakeholders through democratic processes. They can be considered as decision support tools for allocating scarce resources effectively and efficiently.

Effectiveness and efficiency of political institutions, which are embodiments of economic institutions, are the key determinants of the large differences in per capita income across countries [32]. Effective institutions integrate formal and informal (traditional) rules; and effectively configured and implemented institutions minimize transaction costs; enforce contractual agreements; secure property rights; promote effectiveness and efficiency of transactions; foster social harmony; and promote the rule of law (Figure 6). They guide human behavior and interactions; and allocation of scarce resources. Under a given technological and organizational structures, institutions determine the total of transaction costs pertinent to production, distribution, and exchange.

The new institutional economics

Societies with economic institutions that facilitate and encourage accumulation of productive factors, innovation, and efficient and effective allocation of scarce resources should be expected to prosper [32,33]. But, neoclassical economic theory contends that any particular configuration of institutions in an economy does not matter for three reasons: economic outcomes are determined by free-market forces of demand and supply; these forces are expected to lead to Pareto-efficient outcomes (i.e., situations where no one can be made better-off without making someone else worse-off); and institutions do not influence optimality of the rational choice of economic agents.

Much of the theory of welfare economics is rooted in conditions under which Pareto optimum may be achieved. Although it sounds viable logically, the Pareto criterion is highly restrictive, because it provides no guidelines to choice between alternatives, which might involve one person becoming better-off by making another person worse-off. This is one of the serious shortcomings of policies that are prescribed under neoclassical economics.

Based on these and the assumptions for the ideal perfectly competitive market structure, discussed earlier, neoliberalism contends that free market economic forces create self-organizing and regulating spatial mechanisms of the marketplace. Frictionless transactions-it is assumed-take place among all economic agents, operating in an *institutionally vacuum economic environment*. The reality, however, is that without effective institutional arrangements

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

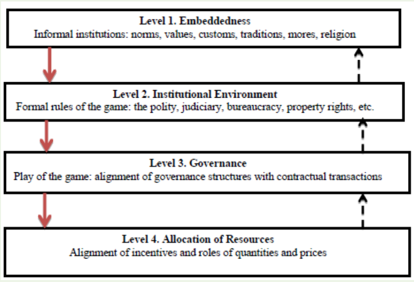

Figure 6: Workings of the new institutional economics.
Source: Adapted from Williamson (2000); each solid (downward) arrow, connecting a higher level with a lower level, indicates that the higher level imposes constraints on the level immediately below, whereas each dashed (upward) arrow, connecting a lower level with a higher level, signals reinforcing *positive feedback*.

any type of development that improves human well-being is an elusive dream. When designing environmental and natural resource management policies, one has to apply both *normative* and *positive* analyses. These two analytical approaches require integration of *formal* and *informal* rules that give durable organizational structure to social interactions of a population [34].

Conformity to prescribed institutional behaviors is expected to be secured by a combination of centrally deployed *coercion* (application of laws), social sanctions (application of informal rules), and *conventions* (mutually agreed-upon aspirations, preferences, and expectations) that make conformity the best response for virtually all members of the group, community, or society concerned.

To illustrate the multidimensionality of the new institutional economics, Williamson [33] provides a model of stratified social institutions (Figure 6).

Figure 6 illustrates the need for incorporating culture-based informal institutions to construct socially and legally sanctioned coherent public policies. Each solid (downward) arrow, connecting a higher level with a lower level, indicates that the higher level (e.g., cultural values) imposes constraints on the level immediately below, whereas each dashed (upward) arrow, connecting a lower level with a higher level, signals feedback.

The informal (unwritten) but culturally embedded institutions of a society shown in level 1 lay the foundation for the formal rules laid out in Level 2. "In all societies from the most primitive to the most advanced, people impose constraints upon themselves to give structure to their relations with others; that the informal constraints are important in themselves (and not simply as appendages to formal rules) can be observed from the evidence that the same formal rules and/or constitutions imposed on societies produce different outcomes" [34]. It is the synergy, generated through the combined effects of the individual institutional elements in levels 1 and 2 that determine effectiveness and efficiency of governance (Level 3) and resource allocation (Level 4). The new institutional economics is mainly concerned with levels 2 and 3, which show that it is the institutional environment which influences governance, play of the game [33].

What is the nature of the relationship between formal and informal constraints on human behavior? Informal constraints, which are embedded in shared values, norms, and social capital of a community (e.g., an Aboriginal community), operate in the shadows of formal rules of government and can either both limit or facilitate socioeconomic performance. Formal rules are produced and enforced by organizations, such as the state and the firm, whereas informal normative rules arise out of networks and are enforced by means of ongoing social relationships. Unlike formal rules, monitoring and evaluating effectiveness of informal institutions is intrinsic to social relationships, and enforcement occurs informally as a by-product of sociocultural values and norms.

Effective political governance system: This subject matter ties it all together. What is an effective political governance system (EPGS)? What I present here is an abstraction of a complex system, which is beyond the scope of a journal article. I define EPGS as asocially, legally, and politically sanctioned dynamic process by which scarce resources (e.g., human capital and physical capital) of a society are allocated among alternative courses of action effectively and efficiently. The following guiding principles-among possible others one might add-characterize EPGS:

- ♣ Personal dedication to serve own people with honesty, personal integrity, and professionalism
- ♣ Deliberative and participatory decision making, involving all stakeholders
- ♣ Horizontally and vertically integrated, coherent, policies implemented through effective institutional configurations
- ♣ Devolution of power to local community-based development organizations
- ♣ Gender equity in sharing decision-making power
- ♣ Effectiveness and efficiency in allocating scarcer sources
- ♣ Strategic vision for the long-run socioeconomic and political outlook
- ♣ Accountability (ability to demonstrate and explain one's actions)
- ♣ Transparency (free flow of information) in all operational and managerial activities
- ♣ Responsiveness to society's preferences, aspirations, and expectations
- ♣ Equity in rights, obligations, benefits, and costs
- ♣ Primacy of the rule-of-law

These, and others one might suggest, are cardinal rules. Collectively, they form a *sacrosanct* code of an EPGS.

Concluding remarks and policy recommendations

When dealing with a complex subject matter like this one, which has far reaching significance, it is very difficult to write a short scientific paper. I have tried to express my thoughts as succinct as I could. I have synthesized and analyzed the extensive literature. I hope this piece motivates others to conduct quantitative and qualitative research. That is, in fact, what I plan to do in collaboration with others who are interested in this important area of scientific inquiry. For now, I close my thoughts with the following policy recommendations:

- Anthropogenic wastes should never exceed the productive and regenerative as well as waste absorption, decomposition, and assimilation capacities of given ecosystems. This is the necessary condition for a *steady state economy*, one which remains within the frontiers of the biosphere through sustainable management of ecosystems.
- When an economy's productive capacity expands, it inevitably encroaches into ecologically sensitive landscapes to devour all natural capital assets, such as timber, fossil fuels, fish, the multiple non-timber forest products, arable land, freshwater, minerals, and metals. Thus, perpetual economic growth in a finite, closed, and non-growing biosphere is an oxymoronic faith.
- Outcomes of the best human ingenuity and the greatest technological advances are bounded by the *Second Law of Thermodynamics*, which dictates that all economic activities have unavoidable adverse effects on the natural environment.
- Growing human population as well as economic production and consumption patterns need to be adjusted to the imperatives of genuine sustainable development: (a) avoid the pursuit for perpetual economic growth; (b) enhance investments in R&D to advance technological progress; (c) promote use of renewable energy; (d) foster green investments that include afforestation, reforestation, effective management of wastes, and application of organic fertilizers; (e) introduce ecological taxation to internalize the social costs of ecological depletion and environmental degradation; (f) introduce a mandatory family planning, which should involve implementation of national childbirth certificate system, to the developing world; and (g) promote a global justice for adapting to the predicaments of climate change.
- The reasons why effectively enforced institutions are indispensable must be explained in terms of both the cognitive capacity limitations of humans-inability to capture, comprehend, process, and use externally received information-and in terms of the social, natural, political, economic, and physical environments where individuals live and work. Against this requirement, neoclassical economics assumes that human beings are rational decision makers, capable of choosing "more" rather than "less"; hence, the marketplace's self-regulating forces are capable of creating optimal equilibrium conditions of demand and supply. But, added to human being's bounded rationality limitations, unpredictability of human life cycle, maintaining order of human interactions, the economic activities of production, distribution, and exchange, the frequent and unpredictable natural disasters, civil conflicts, gains from technological progress and economies of scale, the unavoidable beneficial and harmful externalities, and many other reasons make legally enforced political, social and economic institutions indispensable for GSD; and an *adaptive democratic developmental state*(ADDS)is a necessary requirement.
- *Stark contradictions in the resilient green economy of neoliberalism*: In a competitively globalized marketplace, rhetorical terms, such as "green economy", "green growth", "green jobs", and "sustainable development"-all used misleadingly by the UN's agencies, such as UNEP, the World Bank, and the IMF-are empty slogans. It is unfortunate that many so called experts of these agencies and policy advisors of governments use such terms to bundle up different, often contradictory, interests and strategies masked by impracticable, oxymoronic, themes that include: *low carbon economy, resource-use efficiency, resource substitution, green investments, technological progress, recycling, poverty eradication, and social inclusion*. Neither of these motherhood-wishful themes holds water under the following challenges, whose solutions are necessary conditions to build foundation for GSD:

- Perverse governance systems, manifested through rent seeking-chronic corruption in many nations, are causes of pervasive market distortions.
- Rapidly rising human population in the developing nations is a major driving force of ecological destruction that continues to create overused, fragmented, and ecologically fragile farmlands, revealing some signs of the Malthusian tragic trap.
- Absence of market prices for the three major categories of ecosystem services (*regulating, supporting*, and *enriching-cultural*) (Table 1) invalidates the so called perfectly competitive marketplace, which is rooted in the intricacies of neoclassical economic theory. This is a utopian market structure used to develop theoretical models for empirical exercises.
- Current strategic approaches to green economies give primacy to market commodities over the nonmarket values of the life sustaining multiple services of ecosystems (Table 1).
- *Rebound effects* of strategic policies that result in gains-particularly from efficiencies in using fossil fuel energy-are difficult to measure and consequently not incorporated into GDP accounts.
- Highly competitive and globalized, free market economies, which are dominated by powerful multinational corporations, exacerbate poverty, because they do not offer protection for the well-being of the poorest of the poor.
- Market-based policy instruments designed to preserve environmental quality cannot be effective to safeguard ecological integrity under the perfectly competitive-free-market economic conditions that *externalize* the social costs of environmental pollution and depletion of natural resources.
- In the presence of oligopolistic and monopolistic corporations that gouge consumers to generate *supernormal* profits (net

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.

earnings that exceed all opportunity costs), compared to *normal profits* (net earnings that just cover opportunity costs to induce the firm to remain in operation), it is an oxymoron to think of *resilient green economies*.

In closing, an unfettered economic growth is *unrealistic* and *unsustainable*; and the resilient green economy rhetoric is just a fallacy. What is needed is *reversing* the speed and direction of the anthropocentric excessive economic activities of production, distribution, exchange, and consumption, which are controlled and promoted by profit maximizing multinational corporations. To reverse the unsustainable exploitative trends, collectively configured effective global institutions that enable and oblige humans to be stewards of health and integrity of the biosphere are required. Most importantly, strictly enforced institutions that compel multinational corporations to *internalize* all social costs associated with their overexploitation of natural resources and degradation of the natural environment need to be mandatory to realize GSD. Where the predicaments of inequality, environmental degradation, and climate change are borne by the poor, we cannot even think of GSD.

Acknowledgements

For an intellectually stimulating research environment, I express my indebtedness to my employer, the Canadian Dept. of Natural Resources, Government of Canada. I thank our team leader, Ian Cahill, for his preliminary comments and encouragements. Insightful feedbacks that I received from Shashi Kant, David Nanang, and Derek Sidders are acknowledged gratefully. Last, but not least, comments of the anonymous reviewers are sincerely appreciated. Finally, a disclaimer is warranted: The expressed conclusions and opinions do not in any way imply approval of my employer; and all remaining-undetected errors are mine and mine only.

References

1. Wikipedia (2015) Biosphere.
2. DeWitt CB (2009) Unsustainable agriculture and land use: restoring stewardship for biospheric sustainability. In Robert S. White, FRS (Cambridge University), ed. *Creation incrisis: Christian perspectives on sustainability* (pp. 137-156), SPCK Publishers, UK.
3. Catton Jr W (1980) Overshoot: The ecological basis of revolutionary change. University of Illinois Press, Chicago.
4. Vitousek PM, Mooney HA, Lubchenco J, Melillo JM (1997) Human domination of earth's ecosystems. Science 277: 494-499.
5. Millennium Ecosystem Assessment (2005a) Living beyond our means: natural assets human well-being, a statement from the Board. United Nations Environment Program (UNEP) New York, NY.
6. Rockström J, Steffen W, Noone K, Persson Å, Chapin FS, et al. (2009) Planetary boundaries: Exploring the safe operating space for humanity. Ecology and Society 14: 32.
7. The Brundtland Commission, a.k.a. The World Commission on Environment and Development (1987) Our Common Future. Oxford University Press, New York.
8. Daly HE (1993) Steady-state: A new paradigm. New Literary History 24: 811-816.
9. Georgescu-Roegen N (1975) Energy and economic myths. Southern Economic Journal 41: 347-381.
10. Ayres RU (2007) On the practical limits to substitution. Ecological Economics 61: 115-128.
11. Sen A (1999) Development as freedom. Oxford University Press, London, UK.
12. Stiglitz JE, Sen A, Fitoussi JP (2010) Mismeasuring our lives: why GDP doesn't add up. The New Press, New York.
13. Barrett GW, Odum ER (2000) The twenty-first century: the world at carrying capacity. BioScience 50: 363-368.
14. Ophuls W (2012) Immoderate greatness: why civilizations fail. Create Space Independent Publishing Platform, South Carolina.
15. Nicholson W (2002) Microeconomic theory: basic principles and extensions. South-Western Thomson Learning, Toronto, Ontario.
16. Stiglitz JE (2012) The price of inequality: How today's divided society endangers our future. W.W. Norton & Company, Inc., New York.414 p.
17. Sen A (1999) Human rights and capabilities. Journal of Human Development 6: 151-166.
18. Solow RM (1956) A contribution to the theory of economic growth. The Quarterly Journal of Economics 70: 65-94.
19. Solow RM (1957) Technical change and the aggregate production function. The Review of Economics and Statistics 39: 312-320.
20. Coase RH (1960) The problem of social cost. Journal of Law and Economics 3: 1-44.
21. Friedman M (1962) Capitalism and freedom. University of Chicago Press, Chicago.
22. Klein N (2007) The shock doctrine: The rise of disaster capitalism. Penguin Books, Ltd., New York.
23. Sterman JD (2000) Business dynamics: systems thinking and modeling for a complex world. McGraw-Hill, Toronto, ON.
24. Mukhopadhyay A (2003) Malthus' population theory: an irony in the annals of science. Breakthrough 10: 19-28.
25. Seidl I, Tisdell CA (1999) Carrying capacity reconsidered: from Malthus' population theory to cultural carrying capacity. Ecological Economics 31: 395-408.
26. Putnam RD (1993) Making democracy work: Civic traditions in modern Italy. Princeton University Press, Princeton, NJ.
27. Woolcock M (1998) Social capital and economic development: toward a theoretical synthesis and policy framework. Theory and Society 27: 151-208.
28. Folke C, Hahn T, Olson P, Norberg J (2005) Adaptive governance of social ecological systems. Annual Review Environment Resources 30: 441-473.
29. Armitage D, Berkes F, Doubleday N (2007) Introduction: moving beyond co-management. *In* D. Armitage, F. Berkes, and N. Doubleday, editors. Adaptive co-management: collaboration, learning and multi-level governance. UBC Press, Vancouver, pp. 1-15.
30. Armitage DR, Plummer R, Berkes F, Arthu RI, Charles AT (2009) Adaptive co-management for social–ecological complexity. Frontiers in Ecology and the Environment 7: 95-102.
31. Kriebel D, Tickner J, Epstein P, Lemons J, Levins R, et al. (2001) The precautionary principle in environmental science. Environmental Health Perspectives 109: 871-876.
32. Acemoglu D, Robinson JA (2012) Why nations fail: The origins of power, prosperity, and poverty. Crown Publishers, New York.
33. Williamson OE (2000) The new institutional economics: Taking stock, looking ahead. Journal of Economic Literature 38: 595-613.
34. North DC (1990) Institutions, institutional change and economic performance. Cambridge Univ. Press.New York, NY.

Citation: Ghebremichael A. Frontiers of the Biosphere Inhibit Perpetual Economic Growth: Exploring Pathways to Genuine Sustainable Development. J Environ Soc Sci. 2016;3(2): 127.