Sustainability Brief: Natural Systems and Consumption

1 Background

Historically, economic benefits associated with the natural environment have been described in terms of 'natural resources', emphasizing both non-living (mineral deposits, etc.) and living (timber, fertile soil, fish, etc.) resources of value that can be extracted from the environment for direct use by human beings." (Costanza, et al., 2006) This one-dimensional perspective of the natural environment created and supports a "linear model of resource consumption that follows a 'take-make-dispose' pattern. Companies harvest and extract materials, use them to manufacture a product, and sell the product to a consumer—who then discards it when it no longer serves its purpose." (MacArthur Foundation, 2013)

Under this linear model of consumption global GDP grew twenty times between 1900 and 2000 and created unprecedented levels of material prosperity. Yet, the economic success in past decades has translated into resource consumption levels that are no longer sustainable; between 1980 and 2010 global resource extraction grew from 40 billion tonnes[1] to 65 billion tonnes (Figure 1 below) with an accompanying growth from 9.1 to 9.5 tonnes extracted per capital. (MacArthur Foundation, 2013)

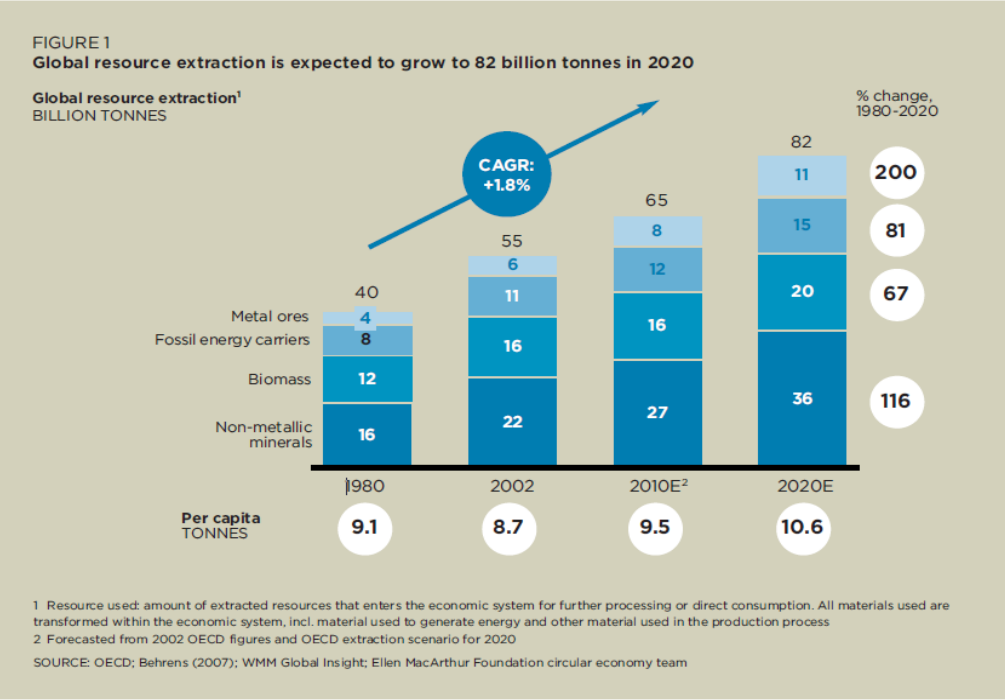

Figure 1 Global Resource Extraction (Ellen MacArthur Foundation, 2013)

[1] The tonne is a metric system unit of mass equal to 1,000 kilograms (2,204.6 pounds).

At the current rate of consumption, around 3.5 planets Earth would be needed to sustain a global population achieving the current lifestyle of the average European or North American. (UN Water) As a result, "nations' efforts to drive their competitive advantage could be a race to disaster: As they maintain their income (or GDP levels), countries are liquidating their assets by running fiscal deficits or overusing biophysical resource stocks". (Global Footprint Network)

More recently, scientists and economists have begun to look at environmental benefits differently. "In this 'natural capital' or 'ecosystem services' framework, the natural environment is viewed as a 'capital asset', i.e., an asset that provides a flow of benefits over an extended period (Costanza and Daly 1992). While inanimate or 'abiotic' resources are not ignored, the emphasis is on the benefits provided by the living environment, usually viewed in terms of whole ecosystems." (Costanza, et al., 2006) This change in perspective is important to address many of today's fundamental challenges. Historic linear consumption patterns ('take-make-dispose') are coming up against constraints on the availability and quality of resources. The challenges on the resource side are compounded by rising demand from the world's growing middle class population. As a result, higher price levels, and more volatility in many markets are driving changes in consumption patterns and product designs to create more 'effective' processes.

2 Sustainability Issues

2.1 Undervaluing of Natural Services

In the current linear economic system natural resources are valued as raw materials for finished goods; however this system has difficultly establishing values for natural systems that provide benefits to society beyond single use inputs. In part this difficulty stems from the fact that benefits from the natural environment are often difficult to quantify in physical and monetary terms, which makes it hard to know exactly what is gained when a landscape is preserved in its untouched state or what we lose when we decide (deliberately or by default) not to protect a natural area. Additionally, some environmentalists object to assigning economic values to nature. This objection may be based partly on "the false presumption that quantifying dollar values for natural 'assets' automatically implies that they can or should be traded in private markets. However, natural assets are, for the most part, public goods. They are often 'non-rival (one person's use does not preclude other's use) and 'non-exclusive' (it is difficult or impossible to exclude people from benefiting from the services). These characteristics are the economist's classic criteria for 'public' goods, and most economists would agree that using unfettered private markets to manage these assets will not maximize social welfare." (Costanza, et al., 2006)

2.2 Scarcity and Degradation

2.2.1 Water

Water is an irreplaceable and essential resource for human health, economic productivity (including agriculture and energy production) and vitality of ecosystems. While 70 percent of the Earth's surface is covered in water the total volume of freshwater resources is only about 2.5 percent of the total volume; and of that, the total usable freshwater supply for ecosystems and humans is less than 1 percent of all freshwater resources. (UN Water) Water scarcity already affects almost every continent and more than 40 percent of the world's population. By 2025, the FAO estimates that 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions. (UN Water) It is estimated that the global gap between existing accessible, reliable supply and 2030 water withdrawals could reach 40 percent, driven in large part by increased demand for energy production, which is highly water-intensive. (McKinsey & Company, 2012)

In the United States the demand for water has stabilized since the 1980s; in 2005[2] about 410,000 million gallons per day of water was withdrawn for use in the United States, the majority from freshwater sources. (USGS, 2005) Thermoelectric (a "flow-through process" that returns the majority of water withdrawn to is source) and irrigation are the two largest users of water in the United States, followed by public supply and industrial uses. While water demand has stabilized, water supply has become increasing scarce in different parts of the country which has led to several high profile concerns, including:

- The Tri-state water dispute between Georgia, Alabama and Florida over water flow from north Georgia's Lake Lanier lasted several decades and resulted in legal action in federal court in 2009 which imperiled the water supply to Atlanta, one of the Nation's fastest growing metropolises. A federal Court of Appeals 2011 decision confirmed the Army Corps of Engineers' authority to regulate the lake for Atlanta's water supply.
- In 2012, increasingly complex water agreements in California's led to a $14 billion plan to build two gigantic tunnels to divert water from the Sacramento River to deliver the water to aqueducts that feed water to large corporate farms and densely populated regions in Central and Southern California. Environmentalists and farmers in northern California have raise concerns over impacts to local ecosystems.
- As of 2013, vast stretches of farmland lying over the High Plains Aquifer no longer support irrigation. While the aquifer's northern reaches still hold enough water to last hundreds of years, the southern regions are increasingly tapped out by ever more intensive farming and drought. Refilling the aquifer would require hundreds to thousands of years' worth of rains.

Further discussion on water availability and sustainability issues can be found in the *Water Availability Sustainability Brief*.

2.2.2 Rare Earth Elements

Rare earth elements (REEs) are a set of seventeen chemical elements, relatively plentiful in the Earth's crust REEs are typically not found in concentrated, economically exploitable ore deposits. Rare earth elements are necessary components in most electronic systems, everything from missile systems to electric cars and cell phones. The mining, refining and recycling of REEs have serious environmental and public health consequences if not managed properly. The physical process of mining REEs, due to their dispersed nature, involves open pit mining which disrupts ecosystems and is a point source for water pollution. During the refining process the release of metal byproducts into the environment, through the air, ground or water, can prove devastating to organisms and constitutes a sever public health threat. The byproducts of mining REEs is another source of environmental concern; improper handling of the mildly radioactive slurry tailings and toxic acids required in the refining process can result in extensive environmental damage and has been linked with increased incidence of birth defects and cancer in communities near mines and refineries.

At one time California was the world's leading producer of REEs but China's lower-cost operations, technical superiority and lax environmental rules have allowed it to become the dominate producer. Currently China produces about 90 percent of the world's supply of REEs (BBC News, 2012) although concerns about China's tightening controls over exports has led to interest in reopening mines in the United States and in other countries with higher safety and environmental standards.

2.2.3 Agricultural Products

Accelerating stress on the world's natural resources will affect food systems around the world. At a global level there is adequate unused potential farmland, however more than half of that land is located in just seven countries in tropical Latin America and sub-Saharan Africa, whereas other regions and countries face a shortage of suitable land. Furthermore, only a fraction of this extra land is realistically available for agricultural expansion

[2] 2005 is the latest United States Geologic Survey compilation of National water use.

as much is needed to preserve forest cover and to support infrastructure development. (FAO, 2002) Additionally, "within the next 15-20 years, the worsening water security situation risks triggering a global food crisis, with shortfalls of up to 30 percent in cereal production." (World Economic Forum)

Further discussion on agricultural sustainability issues can be found in the *Agriculture Sustainability Brief*.

2.2.4 Energy

The use of energy is fundamental to modern society for production, transportation, construction, indoor climate control, etc. The current economic system has a high level of dependence on non-renewable fossil fuels such as coal, petroleum and natural gas, and on uranium-based nuclear electric power. It is projected that emerging economies will drive global energy markets in the future, with the share of non-OECD[3] energy demand rising from 55 percent in 2010 to 65 percent in 2035. China will account for the largest share in the growth (its demand will rise 60 percent) in global energy use, followed by India (where demand will more than double) and the Middle East. (IEA, 2012) Increasing demand for fossil fuels will lead to rising energy prices and increase volatility. In the global market "no country is an energy 'island' and the interactions between different fuels, markets and prices are intensifying." (IEA, 2012) Additionally, some 37% of the world's proven oil reserves, and 19% of proven gas reserves, are also in countries with a high level of political risk[4]. Political decisions drive cartels, subsidies, and trade barriers, all of which can trigger or worsen resource scarcity and push up prices and volatility levels. (MacArthur Foundation, 2013)

Further discussion on energy availability and sustainability issues can be found in the *Energy Sustainability Brief*. Discussions of greenhouse gas emissions and climate change impacts due to energy use are found in the *Climate Change Adaptation and Natural Hazards Sustainability Brief*.

2.3 Increased Demand

The OECD estimates that the global middle class will increase from 1.9 billion in 2009 to 4.9 billion in 2030 with almost all of the growth (85%) coming from the Asia-Pacific region. (Kharas, 2010) China and India, the two largest countries by population, are leading this growth. Each is poised to undergo a significant economic transition in coming decades, which indicates that a stunning number of new middle-class consumers could be entering the global economy if the two countries continue their current growth patterns. This explosive growth in the middle-class is a "time bomb of consumption" (See Figure 1 from The MacArthur Foundation right) as the "advent of disposable incomes to many more households means that a large number of consumers will move from 'doing without' to enjoying the benefits of their improved financial position by buying more items." (MacArthur Foundation, 2013)

[3] The Organization for Economic Co-operation and Development (OECD) has 34 member countries including many of the world's most advanced countries but also emerging countries like Mexico, Chile and Turkey.
[4] High level of political risk as defined by the *Economist Intelligence Unit's* *Political Instability Index*

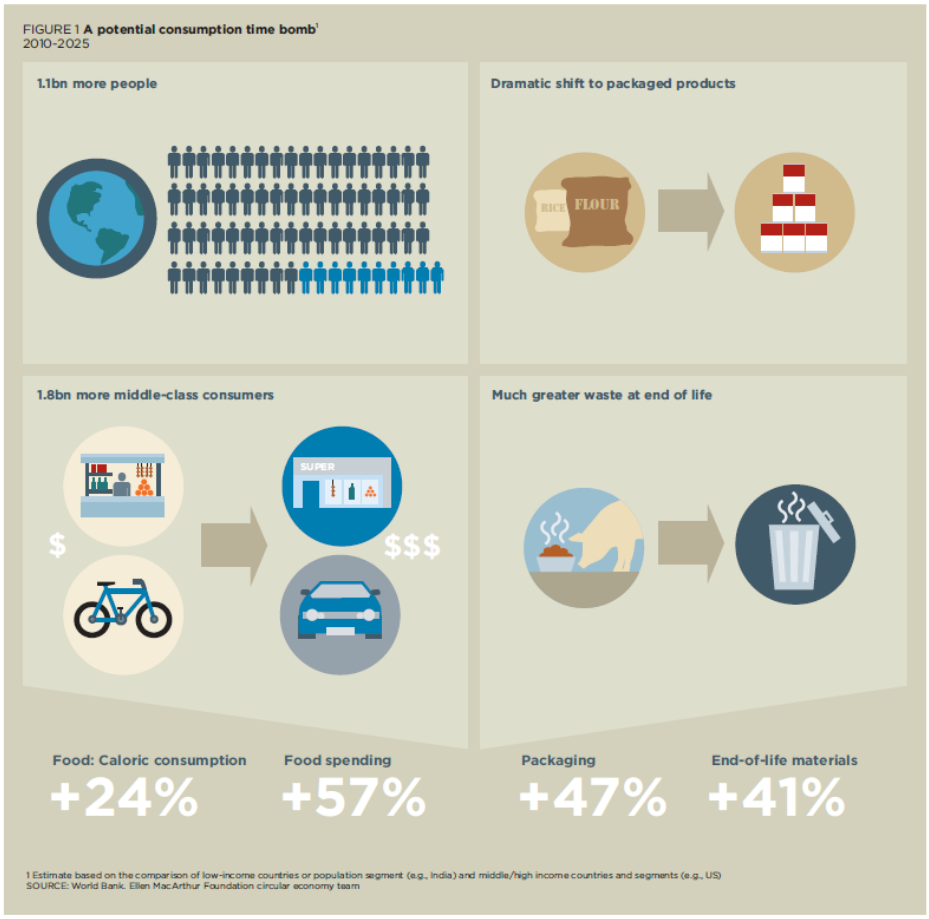

Figure 2 Consumption Issues (Ellen MacArthur Foundation, 2013)

3 Sustainability Responses

3.1 Beyond the Tragedy of the Commons

Garret Hardin's "tragedy of the commons" which portrays users of a common-pool resource trapped in an inexorable tragedy of overuse and destruction is a widely accepted, yet over simplistic view of the exploitation of natural systems. The tragedy of the commons is often used as a justification for government ownership, regulation and management of natural systems. Some scholars propose that government-owned protected areas are the "only" way to ensure that natural systems and biodiversity are protected around the world. (See *Biodiversity Sustainability Brief* for further discussion of protected areas.) Studies of protected areas, however, have found that the "frequent eviction of indigenous peoples who had lived in a region for multiple centuries prior to the establishment of the park in their territory has not produced the positive results expected." (Ostrom, 2010)

Worldwide there are numerous successful models of regulation and management of natural systems that prevent overexploitation while providing equitable distribution of benefits. While "one size fits all" policies are not effective at managing natural systems several characteristics are common to successful long sustained regimes as contrasted to the cases of failure: clear user and resource boundaries; appropriation and provision rules that are congruent with local social and environmental conditions; the distribution of costs is proportional to the distribution of benefits; collective choice arrangements; monitoring of the users and resource which is accountable to and/or performed by the users; graduated sanctions; conflict resolution mechanisms; a minimal recognition of rights by the government; and nested enterprises that link the common-pool enterprise with a larger social-ecological system. (Ostrom, 2010)

These long sustained natural system management regimes require and in turn foster high levels of social capital, while providing increase economic competitiveness to their community in addition to the benefits received from the natural system itself. Further discussion on *social capital, economic competitiveness* and *biodiversity* can be found in the *Sustainability Briefs* relating to those topics.

3.2 Changing Value System for Natural Systems

"The linear 'take-make-dispose' economic model relies on large quantities of easily accessible resources and energy. Much of our existing efforts to decouple the global economy from resource constraints focus on driving 'linear' efficiencies—i.e., a reduction of resources and fossil energy consumed per unit of manufacturing output. Proponents of the circular economy argue that focusing on efficiency alone will not alter the finite nature of resource stocks, and—at best— simply delays the inevitable." (MacArthur Foundation, 2013) A change of the entire value system for natural resources is necessary.

New studies are being done to document the economic value of natural lands. The Value of NJ's Ecosystems Services reviewed over 100 studies to document significant economic value for wetlands, marine ecosystems, forests, urban green spaces, beaches, agricultural lands and open fresh water and riparian buffers. While these are primarily environmental benefits such as natural water filtration and waste treatment, they also include recreation and aesthetic benefits. (Costanza, Wilson, Troy, Voinov, Liu, & D"Agostino, 2006)

The economic benefits generated by protected open space accrue in different ways – some are direct revenue streams to individuals or governments, some represent asset appreciation value, some accrue in the form of avoided costs. Individually they range in hundreds of millions of dollars per year for the region studied. (Economy League of Greater Philadelphia; Econsult Corporation; Keystone Conservation Trust, 2011)

Further discussion on the value of natural lands can be found in the *Economic Competitiveness Sustainability Brief*.

3.3 Changing the economic model

The new resource context calls for an upgrade of the classical model of competitive advantage that addresses the rapidly shifting resource dynamics. The Global Footprint Network, co-founded by Mathis Wackernagel, believes that the next generation of competitiveness models "needs to revisit the concept of well-being beyond GDP. GDP is blind to many factors, including the inequalities and limitations that can lead to social tensions and unrest. To maintain social stability and human progress, the new competitiveness models must consider factors such as public health and life expectancy, access to education, wealth creation, and a sense of fairness and equality." (GFN)

Some emerging economic models have already begun to transition away from the traditionally linear model. "A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." (MacArthur Foundation, 2013)

Further discussion of economic competitiveness, including alternatives to GDP as an indicator and sustainable degrowth theories, can be found in the *Economic Competitiveness Sustainability Brief*.

3.4 Changing Consumption Patterns

Emerging trends indicate that there is a pervasive shift in consumer behavior**.** New economic models, such as the sharing or collaborative economy, replace the concept of the consumer with that of a user. "Technology has reduced transaction costs, making sharing assets cheaper and easier than ever—and therefore possible on a much larger scale. The big change is the availability of more data about people and things, which allows physical assets to be disaggregated and consumed as services. (The Economist, 2013)

The change in consumer preferences has profound business implications. "Rachel Botsman, the author of a book on the subject, says the consumer peer-to-peer rental market alone is worth $26 billion." (The Economist, 2013) Consumer preferences are still driven by price, but "consumers increasingly want companies to behave more responsibly and provide sustainable products at the right price and performance." "Reaching price parity or delivering more cost effective alternatives (such as services instead of goods or collaborative consumption) could create lucrative new markets." (World Economic Forum, 2012)

3.5 Changing Design Processes

In the past decade "material intensity of production has been decreasing by 1 percent per year", however "the consumption of resources in absolute terms continues to increase with the world's rising population and growing economic demand." (UNEP, 2012) These trends indicate that continued investment in natural resource and energy efficiency is needed to change the resource intensity in the production process. "In the consumer-focused industries and along their value chains, individual companies will need to consider making resource efficiency and environmental competitiveness a core element of their strategy and business models." (World Economic Forum, 2012) A step beyond efficiency, *eco-effectiveness, "*proposes the transformation of products and their associated material flows such that they form a supportive relationship with ecological systems and future economic growth." (MacArthur Foundation, 2013) The goal is to move from the cradle-to-grave flow of materials to a cyclical, cradle-to-cradle process that allows materials to maintain their status as resources and accumulate intelligence as they are "up-cycled".

3.6 Restoration and Regeneration

The previous several 'sustainability responses' deal with managing and reducing exploitation of natural systems, in many cases however, the natural system has already been degraded, damaged, transformed or entirely destroyed as the direct or indirect result of human activities. "Ecological restoration is an intentional activity

that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability." (SER, 2004) In the United States the Surface Mining Control and Reclamation Act (SMCRA) of 1977 requires that open pit mines, like those used for coal mining, be reclaimed or restored to a natural or economically usable purpose following the cessation of mining operations. Under the leadership of the Office of Surface Mining Reclamation and Enforcement (OSM) reforestation has been promoted as an appropriate and desirable approach to reclaiming mined lands to support forested land uses and provide environmental, economic and community benefits. A more recent OSM initiative goes beyond the physical reclamation of mined lands to encompass efforts to revitalize communities left impoverished and degraded by past coal mining. (OSM, 2013) Promoted by NOAA for habitat conservation and restoration, "living Shorelines" are another ecological restoration technique aimed at removing hardened structures such as bulkheads, revetment and concrete seawalls along coastlines and rivers. This approach uses plans, sand and limited use or rock to provide shoreline protection and maintain valuable natural systems. While possibly ideal for many locations along New Jersey's sheltered coastline, the State's current general permitting process does not easily allow for the installation of living shorelines.

Regenerative design integrates the concepts of reclamation and restoration into a development process that "emphasizes a co-evolutionary, partnered relationship between humans and the natural environment, rather than a managerial one that builds, rather than diminishes, social and natural capitals." (Cole, 2012) Regenerative design pushes beyond "green" or "sustainable" development, which only seek to minimize damage to the environment and human health, to extend the dialogue into a broader conversation about the role of development as a source for "harmonizing the multiple dimensions of Place—the diverse historical, ecological, cultural, economic, and political forces that too often turn communities into battlegrounds. (Regenesis, 2008)

4 Implications

Changing view of natural systems and new methods for determining their value should provide elected leaders, policy makers, and the public with new perspectives on the value of natural systems and contribute to informed decisions concerning future exploitation. Regulation and management of these natural systems will need to take into consideration the local social and environmental context, foster high levels of social capital, distribute benefits equitably, and provide increased economic opportunities to their communities in order to be sustainable.

Shifts in consumption patterns and changes in production process as part of a new economic model, such as the circular economy, could foster an estimate of net material cost saving benefits of more than USD 600 billion per year by 2025, (minus material costs incurred during reverse-cycle activities). (MacArthur Foundation, 2013) The shift towards buying and selling services and designing products for reuse should also spur positive secondary effects such as a wave of innovations and employment in growth sectors of the economy, while increasing competitiveness in the global marketplace.

Increasing interest and emphasis on ecological restoration and regenerative design will begin to move human environments and activities from sources of destruction and towards "engines of positive evolutionary change for all living systems." (Regenesis, 2008)

5 Defining and Tracking Sustainability

Consumption and management of natural resources and capital are sustainable when:

- Exploitation of "renewable" natural resources are at the same rate as their regeneration cycle
- Use of virgin non-renewable natural resources is minimized and reuse of materials is maximized
- The use of hazardous materials and toxic chemicals is reduced

- The generation of waste is reduced through minimization of materials needed, reuse of materials and recycling of materials
- The appropriation and provision of natural resources are congruent with local social and environmental conditions
- Distribution of benefits is proportional to the distribution of costs
- A competitive, inclusive economy delivers full and productive employment for all and fosters efficient social protection systems

See Table 1 for a preliminarly list of indicators and targets.

6 Conclusion

Natural resource scarcity and consumptions patterns are issues of increasing concern. With the rise of the global middle class consumption of resources and goods is destined to increase putting greater and greater pressures on markets. New economic models will need to replace the current 'take-make-dispose' pattern with industrial systems that are restorative or regenerative by intention and design. 'Consumers' will need to become 'users', which calls for a new contract between businesses and their customers. This transformation has many challenges, but provides numerous benefits; mitigation of price volatility and supply risks, sectoral shifts and possible employment benefits, reduced externalities and lasting benefits for a more resilient economy.

Table 1: Preliminary Natural Capital and Consumption Sustainability Indicators and Targets

Sustainability Definition	Preliminary Indicators	Preliminary Targets	Scale of Analysis	Availability and Period of Data
Exploitation of "renewable" natural resources are at the same rate as their regeneration cycle	Determine the current rate of use versus the regeneration cycles of critical materials to set baseline	Reductions over time to achieve balance	• Global • National • Regional • State	National and state data on renewable resources industries consolidated for global impacts
Use of virgin non-renewable natural resources is minimized and reuse of materials is maximized	Determine the current rate of use and anticipated remaining capacities. New industry materials design to reduce new materials and expand reuse of manufactured materials		• Global	National and state data on non- renewable resources industries consolidated for global impacts
The use of hazardous materials and toxic chemicals is reduced	• Tons of hazardous or toxic materials produced	• Reduce the use of hazardous materials and toxic chemicals and the generation of wastes, such as non-biodegradable materials and the emission of pollutants	• Global • National • Regional • State	State level data on hazardous wastes and non-hazardous wastes
The generation of waste is reduced through minimization of materials needed, reuse of materials and recycling of materials	• Tons of waste produced (net, per person) • Health outcomes	• See Indoor Environmental Health Hazards, Air Quality, and Public Health Sustainability Briefs for more info	• Global • National • Regional • State	US EPA data on municipal wastes, etc

Sustainability Definition	Preliminary Indicators	Preliminary Targets	Scale of Analysis	Availability and Period of Data
The appropriation and provision of natural resources are congruent with local social and environmental conditions	• New expanded GDP indicators	•	• Global • National • Regional • State	• New expanded GDP indicators
Distribution of benefits is proportional to the distribution of costs	• New expanded GDP indicators	•	• Global • National • Regional • State	• New expanded GDP indicators
A competitive, inclusive economy delivers full and productive employment for all and fosters efficient social protection systems	• New expanded GDP indicators	•	• Global • National • Regional • State	• New expanded GDP indicators

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