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The future value of ecosystem services: Global scenarios and national implications

Ida Kubiszewski [a,*], Robert Costanza [a], Sharolyn Anderson [b], Paul Sutton [c]

[a] Crawford School of Public Policy, The Australian National University, Canberra, ACT 2601, Australia
[b] National Parks Service, Fort Collins, Colorado, USA
[c] University of Denver, CO, USA

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ABSTRACT

We estimated the future value of ecosystem services in monetary units for 4 alternative global land use and management scenarios based on the Great Transition Initiative (GTI) scenarios to the year 2050. We used previous estimates of the per biome values of ecosystem services in 2011 as the basis for comparison. We mapped projected land-use for 16 biomes at 1 km^2 resolution globally for each scenario. This, combined with differences in land management for each scenario, created estimates of global ecosystem services values that also allowed for examinations of individual countries. Results show that under different scenarios the global value of ecosystem services can decline by $51 trillion/yr or increase by USD $30 trillion/yr. In addition to the global values, we report totals for all countries and maps for a few example countries. Results show that adopting a set of policies similar to those required to achieve the UN Sustainable Development Goals, would greatly enhance ecosystem services, human wellbeing and sustainability.

1. Introduction

Ecosystem services are a major contributor to sustainable human wellbeing. Between 1997 and 2011, the global value of these services has decreased by an estimated USD 20 trillion/yr. due to land use change (Costanza et al., 2014). We synthesized three existing sets of scenarios (Raskin et al., 2002; Bateman et al., 2013; Costanza et al., 2015) to develop and evaluate the future value of global ecosystem services under four alternative land-use and management scenarios (Table 1). The scenarios are based around the four 'Great Transition Initiative' (GTI) archetypes (Hunt et al., 2012) created by Raskin et al. (2002). They provide a range of plausible futures that incorporate different policies and world views and their effects on a range of issues, including climate change, economics, overall wellbeing, and land and water use and management (Fig. 1). A large number of studies use a broad range of future scenarios. Van Vuuren et al. (2012) surveyed these studies and concluded that: "Comparison of these studies shows that there is actually a limited set of scenario families that form the basis of many scenarios used in different environmental assessments." This is a conclusion shared by Hunt et al. (2012) and Costanza et al. (2015). Similar, broad range land-use and social-economic scenarios, within these archetypes, are also being used by the IPCC (O'Neill et al., 2017; Popp et al., 2017; Riahi et al., 2017). The GTI scenarios, used in this paper, fit this set of families or 'archetypes' and include aggregate land use projections tied to the scenarios. These scenarios are best thought of as 'exploratory' (IPBES, 2016) in that they represent different plausible futures based on storylines, as opposed to 'target-seeking', 'policy-screening', or 'retrospective' scenarios.

We estimated the implications of these scenarios and their land use and management assumptions for the value of ecosystem services to 2050 (Fig. 2).

The GTI scenarios are described in more detail later, but in summary are:

1. **Market Forces (MF):** an economic and population growth archetype based on neoliberal free market assumptions;
2. **Fortress World (FW):** an archetype in which nations and the world become more fragmented, inequitable, and head towards temporary or permanent social collapse;
3. **Policy Reform (PR):** a continuing economic growth archetype, but with discipline/restraint/regulation based on assumptions about the need for government intervention and effective policy; and,

* Corresponding author.
E-mail addresses: ida.kub@gmail.com (I. Kubiszewski), rcostanz@gmail.com (R. Costanza), sharolyn.anderson@unisa.edu.au (S. Anderson), paul.sutton@unisa.edu.au (P. Sutton).

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Table 1
This table shows the 12 scenarios that were combined from 3 different sources to make the four future scenarios used in this paper. It also shows the characteristics and variable of these four scenarios.

ELD Scenarios	1997	2011	1. MF	2. FW	3. PR	4. GT
Great Transition Initiative (GTI)			Market Forces	Fortress World	Policy Reform	Great Transition
Costanza et al. (2014)			Free Enterprise	Strong Individualism	Coordinated Action	Community Well Being
Bateman et al. (2013)			Focus on Market Growth	Maintain Current Practices	Green and Pleasant Land	Conservation Fully Implemented
Population (e9)	5.9	7	9.08	9.53	8.68	8.08
Urban pop (e9)	2.75	3.5	6.25	6.57	5.99	5.57
Rural pop (e9)	3.15	3.5	2.83	2.96	2.69	2.51
Global GDP (e12 $2007)	53	87	188	162	180	170
Inequality (Richest 10%/Poorest 10%)		16	29.4	53	14.9	7.1
Urban land (e6 ha)	332	350	554	675	490	397
Cropland (e6 ha)	1400	1672	1757	1782	1733	1676
Forest (e6 ha)	4855	4261	3450	3541	3989	4313
Grass/Rangeland (e6 ha)	3898	4418	3991	3696	4219	4483
Desert (e6 ha)	1925	2159	3396	3494	2427	1924

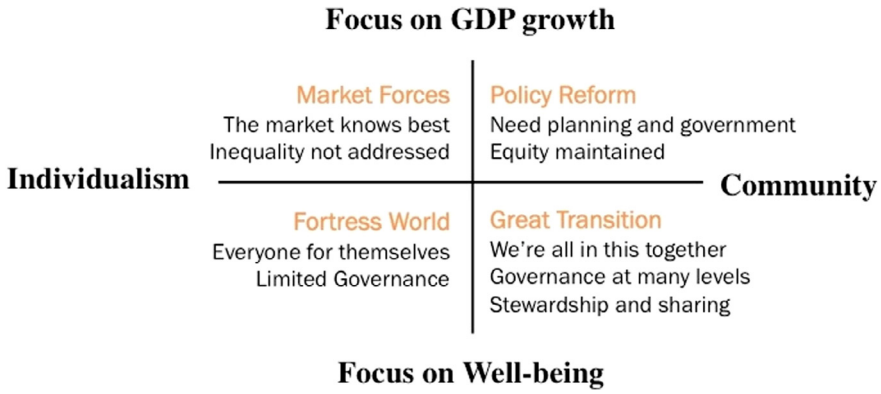

Fig. 1. The two axes on which the four scenarios are laid out on. This is a commonly used method in developing scenarios. The horizontal axis shows the range between giving priority to the individual or collective (community) interests. The vertical axis distinguishes between a focus on GDP growth and materialistic consumption versus a focus on the well-being of humans and the environment.

4. **Great Transition (GT):** a transformation archetype based on assumptions about limits to conventional GDP growth and more focus on environmental and social wellbeing and sustainability.

The ecosystem services in these four scenarios were estimated globally and we also report the implications for selected countries, including Australia, Brazil, China, Germany, India, South Africa, and the United States. These countries were chosen as examples from each of the continents (two from Asia), excluding Antarctica. Results for all countries are included in Supplementary information (Table S1).

2. Global value of ecosystem goods and services

Ecosystems provide the life support system of our planet (Costanza et al., 1997, 2014; Millennium Ecosystem Assessment (MEA), 2005). However, over the past several decades, the goods and services[1] that they provide have been significantly degraded (Sutton et al., 2016). In 2011, the total value of global ecosystem services were estimated to be USD 125 trillion/yr (Costanza et al., 2014). This value was estimated to be a decrease of USD 20.2 trillion/yr from 1997 due to land use and management changes[2] (Costanza et al., 1997, 2014) – a trend which is currently continuing. Interest in ecosystem services in both the research and policy communities is growing rapidly (Balvanera et al., 2012; Braat and de Groot, 2012; Costanza and Kubiszewski, 2012; Egoh et al., 2012; Maes et al., 2012; Molnar and Kubiszewski, 2012; Pittock et al., 2012).

Before the last US presidential election, a memo from President Obama to US Federal agencies directed them to incorporate ecosystem services into their planning, investment, and regulations[3]. The memo also stated that such consideration of ecosystem services could occur "through a range of qualitative and quantitative methods to identify and characterize ecosystem services, affected communities' needs for those services, metrics for changes to those services and, where appropriate, monetary or nonmonetary values for those services" (Donovan et al., 2015). The status of this memo under the new administration is, of course, uncertain. But several other countries have also begun to incorporate ecosystem services in their policies. The European Union (EU) has mandated all member countries within the EU to produce national ecosystem service assessments to then be used in policy and decision-making. On the international level, several other initiatives, networks, and platforms

[1] For simplicity, we refer to all the benefits that ecosystems provide to humans as "ecosystem services," recognizing that they cover a large range of goods and services, including provisioning, regulating, cultural, and supporting services. See references 6–8 for more detailed descriptions.

[2] Changes in values result from both changes in supply and changes in valuation and valuation methodology. Costanza et al. (2014) included an analysis of both of these effects. Here we list only the results using the most recent values and methods.

[3] https://www.whitehouse.gov/blog/2015/10/07/incorporating-natural-infrastructure-and-ecosystem-services-federal-decision-making.

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