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Ecological economics of coastal disasters: Introduction to the special issue

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ABSTRACT

Coastal disasters are increasing in frequency and magnitude—measured in terms of human lives lost, destroyed infrastructure, ecological damage and disrupted social networks. Hurricane Katrina and the Indian Ocean tsunami illustrate the severe and widespread impacts of such disasters on human well-being. The proximate cause of most of these disasters is “forces of nature”. However, human decisions, driven largely by economic forces, do much to aggravate these natural disasters—for example, coastal mangroves and wetlands protect coastal communities from wave surges and winds, but are rapidly being converted for the production of market goods, and anthropogenic climate change driven by the energy use of our economy may exacerbate coastal disasters in several ways. The goal of economics should be to improve the sustainable well-being of humans. Our well-being is generated in part by the production of market goods and services, but also by the goods and services provided by nature, by social networks and norms, by knowledge and health–in short: built, natural, social and human capital, respectively. In seeking to increase human well-being solely by maximizing the monetary value of market goods (built capital), our current economic system may be doing more to undermine our sustainable well-being than to improve it, a point made clear by the growing negative impacts of coastal disasters. An economic system should allocate available resources in a way that equitably and efficiently provides for the sustainable well-being of people by protecting and investing in all four types of capital. This is what ecological economics seeks to do. This article introduces ten papers that apply the four capital framework to the analysis of coastal disasters, seeking to understand their impacts and how to mitigate them, how to predict and plan for them, and how to use this information to redesign coastal areas in a more sustainable and desirable way.

1. Coastal disasters

The damages from natural disasters have been increasing exponentially over the last several decades (Millennium Ecosystem Assessment, 2005). Much of this damage has been concentrated on the coasts. The Asian Tsunami and Hurricane Katrina are just two recent examples. Part of the reason for this is population growth and the increasing amount of

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infrastructure built in coastal areas susceptible to damage. Another part of the reason is the poor placement of this infrastructure and damage to the natural capital which could have protected it if it had been designed and built with ecosystem services in mind. For example, had the coastal wetlands fringing New Orleans been intact, there is a good chance that hurricane Katrina would not have overtopped the levies and flooded a large part of New Orleans. A third part of the reason is the increasing severity and frequency of storms affecting coastal regions, probably as the result of cyclical trends aggravated by global warming. For example, recent studies have shown that the destructive powers of hurricanes are increasing worldwide and the frequency of category 4 and 5 hurricanes has increased dramatically in the last 2 decades in the Atlantic (Webster et al., 2005; Emanuel, 2005). A fourth reason is that sea level is rising in many parts of the coast (accelerated by global warming) and many coastal areas are subsiding, making them even more vulnerable over time.

Coastal Louisiana, for example, was susceptible to all of these effects. The wetlands surrounding New Orleans are part of the Mississippi deltaic plain, a huge area of coastal marshes that were built by the accretion of sediments over the last 10,000 years. Because the Deltaic plain was constructed of newly deposited sediments, it has been compacting and subsiding naturally. But the rate of new sediment accretion has historically more than kept up with the rate of subsidence, allowing a net increase in coastal marsh area. Beginning in the 1930s, the Corps of Engineers began to levee the river in order to enhance navigation and prevent flooding. The heavily managed Mississippi River, which had a much reduced sediment load due to dam construction upstream, was forced by this levee construction to dump most of its remaining load off the continental shelf into the deep waters of the Gulf of Mexico. It is not only the sediments that help build coastal marshes; the freshwater counteracts salt water intrusion and nutrients spur organic soil formation—the major way that new soil is formed in the delta. When the river flow is not delivered to the wetlands to counteract subsidence and sea level rise, the wetlands disappear along with their storm protection. The coastal Louisiana wetlands have been lost at a rate as high as 100 km^2 (39 $mile^2$) per year, and barrier islands have been rapidly eroding as well. Overall, 4800 km^2 (1800 $mile^2$) of wetlands has been lost since the 1930s due to a combination of land subsidence, sediment deprivation due to levee construction, sea level rise, and oil and gas exploration and extraction activities (Day et al., 2005). The mainstem Mississippi river was managed to allow deepwater shipping and commerce in the New Orleans region and to stop flooding of developed areas, but this management regime led to increasing vulnerability. So what happened in New Orleans, while a terrible natural disaster, was also the ultimate result of excessive and inappropriate management of the Mississippi River, inadequate preparation, a failure to act in time on plans to restore the wetlands and storm protection levees, and the expansion of the city into increasingly vulnerable areas. These areas were not always below sea level. Up until the first quarter of the 20th century, the city was mostly above sea level. It was the drainage of the wetlands that promoted soil oxidation and rapid subsidence.

The damages from the Asian Tsunami had a similar confluence of factors. Some of the countries that suffered the worst have relatively dense and rapidly growing coastal populations, and have been experiencing accelerated degradation of coastal ecosystems (Martinez et al., 2007-this issue; Adger et al., 2005). Areas where coastal mangroves and coral reefs remained intact sustained much less damage from the Tsunami than areas where the mangroves and reefs had been removed and coastal developments were directly adjacent to open water (Danielsen et al., 2005; Marris, 2005).

What is needed for the coast, and for society in general, is a new vision—one that can provide a sustainable and high quality of life for *all* citizens, while working in partnership (not in futile opposition) with the natural forces that shaped it. Ecological economics can provide that vision. This special issue is devoted to the ecological economics of coastal disasters. It contains 9 papers that address four key questions: (1) what have been the impacts of coastal disasters on not only the built infrastructure on the coasts, but also on the human, social, and natural capital of the coasts? (2) How can we better predict and plan for coastal disasters? (3) How can we mitigate the negative effects of coastal disasters? (4) How can we use this information to redesign coastal areas in a more sustainable and desirable way?

2. Ecological economics and coastal disasters

Before discussing these questions, we need to revisit the basic vision of ecological economics. What is the economy and what is it for? The purpose of the economy *should be* to provide for the sustainable well-being of people. That goal encompasses material well-being, certainly—but also anything else that affects well-being and its sustainability. There is a substantial new research on this "science of happiness" that shows the limits of conventional economic income and consumption in contributing to well-being (Kasser, 2003; Easterlin, 2003; Layard, 2005). These studies show that well-being tends to correlate well with health, level of education, and marital status, and not very well with income. Layard concludes that current economic policies are not improving happiness and that "happiness should become the goal of policy, and the progress of national happiness should be measured and analyzed as closely as the growth of GNP." There is also substantial and growing evidence that natural systems contribute heavily to human well-being. It has been estimated that the annual, non-market value of the earth's ecosystem services is substantially larger than global GDP (Costanza et al., 1997). The Millennium Ecosystem Assessment (2005) is a global compendium of ecosystem services and their contributions to human well-being.

So, if we want to assess the "real" economy–all the things which contribute to real, sustainable, human welfare–as opposed to only the "market" economy, we have to measure the non-marketed contributions to human well-being from nature, from family, friends and other social relationships at many scales, and from health and education. One convenient way to summarize these contributions is to group them into four basic types of capital that are necessary to support the real, human-welfare-producing economy: built capital, human capital, social capital, and natural capital.

The market economy covers mainly built capital (houses, factories, offices, and other built infrastructure and their products) and part of human capital (spending on education and labor), with some limited spillover into the other two. Human capital includes the health, knowledge, and all the other attributes of individual humans that allow them to function in a complex society. Social capital includes all the formal and informal networks among people: family, friends, and neighbors, as well as social institutions at all levels, like churches, social clubs, local, state, and national governments, NGOs, and international organizations. Natural capital includes the world's ecosystems and all the services they provide. Ecosystem services occur at many scales, from climate regulation at the global scale, to flood and storm protection, soil formation, nutrient cycling, recreation, and aesthetic services at the local and regional scales.

An economic system should allocate available resources in a way that best provides for the sustainable well-being of people, and to do so must protect and invest in all four types of capital. Market economies use the price mechanism to allocate available resources towards end uses that maximize the monetary value of market goods, systematically prioritizing investments in built capital. Prices also serve to ration consumption of market goods. But the price mechanism fails for resources that cannot be exclusively owned, such as storm protection services provided by coastal ecosystems, and will systematically favour the allocation of ecosystem structure towards the production of market goods rather than the provision of non-marketed ecosystem services. Moreover, it is highly inefficient to ration resources that are not depleted by use, such as many ecosystem services, or those that are actually improved through use, such as social capital and information. For example, if we use prices to ration the use of new information about abundant, clean and renewable energy sources, poorer countries such as India and China may be unable to afford them, so the new technologies would do little to slow global climate change. By emphasizing only one allocative mechanism and type of value, the market economy fails to provide the proper balance of capitals, and is thus inefficient at sustaining our well-being.

Ecological economics in contrast recognizes the importance of all four types of capital and further recognizes that they interact in a complex and dynamic system—natural capital sustains the other forms of capital, social capital is an essential component of the economic institutions responsible for allocation, technology and information (human capital) create new uses for natural capital, and so on. Within this system, different properties and different types of value emerge at different temporal and spatial scales. Uncertainty and ignorance are prevalent. Under such circumstances, we must use multiple mechanisms to allocate resources towards multiple values created by the flow of goods and services from all four types of capital. Furthermore, we must adopt an adaptive management approach in which we act on partial knowledge, then adjust our actions as we gain new knowledge.

Coastal disasters illustrate the importance of adopting the vision offered by ecological economics. In general, coastal areas exhibit unusually high concentrations of all four types of capital. Measured both in terms of biological productivity and the value of ecosystem services, coastal systems have the most productive natural capital. For example, the Mississippi delta is one of the most concentrated areas of natural capital in North America. This is reflected in the largest fishery and most important flyway terminus in the US, abundant wildlife, high water cleansing ability, and high storm protection ability. Globally, over 40% of the human population and a similar percentage of built capital are found in the coastal zones, and these percentages are increasing (Martinez et al., 2007-this issue). Humanity's historical dependence on maritime transportation has facilitated trade, communication and travel among coastal populations, presumably building social networks and enhancing social capital in the process. Coastal disasters command our attention precisely because coastal systems exhibit such a high concentration of capital assets, and if we are to maximize the contributions of coastal areas to sustainable human well-being, we pay attention to all four types of capital.

The 10 papers in this special issue apply the general "4 capital" framework of ecological economics to various aspects of coastal disasters.

To further set the context, Martinez et al. (2007-this issue) look at the ecological, economic and social importance of the coasts from an ecological economics perspective. They estimate that 70% of the value of global ecosystem services are provided by coastal systems, which also harbor 41% of the global human population and 21 of 33 global megacities.

Pérez-Maqueo et al. (2007-this issue) follow this with a global assessment of storm intensity, coastal disasters and vulnerability from an ecological economics perspective. They conclude that the complex interactions among the four types of capital and the many feedback loops that are involved need to be considered to achieve effective disaster risk reduction. A related paper (Costanza et al., in press) quantifies the value of coastal wetlands in the US for protection from hurricanes.

Bagstad et al. (2007-this issue) look at taxes, subsidies, and insurance as drivers of United States coastal development. Poorly planned development policies and practices are seen to erode the natural capital of coastal regions, eliminating existing landscape protection from intense wind and waves. They propose more sustainable, just and efficient alternatives that will help regions mitigate and adapt to coastal catastrophes.

Masozera et al. (2007-this issue) look at the distribution of impacts of natural disasters across income groups, and make policy recommendations for reducing vulnerability. They examine whether neighborhoods in New Orleans were impacted differently by Hurricane Katrina based on pre-existing social, physical and economic vulnerabilities. They conclude that while Katrina caused significant flood damage across neighborhoods and income groups, upper income groups were better able to cope with the aftermath of the storm.

Gaddis et al. (2007-this issue) look at full cost accounting of coastal disasters and their implications for planning. They note how the spatial and temporal magnitude and scale of costs are captured differently in typical cost accounting and a more comprehensive (full cost) approach. The implications of full cost accounting are that continued population development as well as the maintenance of current settlements in particular regions along the coasts may not be in the society's best interest.

Duxbury and Dickinson (2007-this issue) develop principles for the sustainable governance of the coastal zone that would allow coastal communities to continue to live in these regions without further degrading natural capital. They develop their principles based on the Lisbon principles for sustainable governance of the oceans (Costanza et al., 1998).

Baker and Refsgaard (2007-this issue) look at the issues of institutional development and scale matching in disaster response management, emphasizing their role as central components of socio-economic resilience. They conclude that new threats will require increased coordination, higher levels of institutional flexibility, and greater attention to issues of connectivity in disaster response management.

Farley et al. (2007-this issue) analyze the role of "focusing events" in opening the policy window for ecological economics, using hurricane Katrina as a case study. They argue that ecological economists have failed to galvanize public acceptance for the policy goals of sustainable scale and just distribution, failing to effectively communicate their perspectives on problem definition and/or policy solutions to policy makers and the voting public. They also offer suggestions for how to overcome this problem.

Gately (2007-this issue) estimates the Energy Return on Investment (EROI) from coastal and offshore oil and gas operations, using a computer model to simulate the productivity dynamics of offshore energy extraction in the Gulf of Mexico over a twenty-year period (1985–2004). The model estimates the EROI of the "offshore process" to range from 10 to 25, depending on which indirect energy costs are included. Though not addressed explicitly in his article, the increasing severity and frequency of storms in the Gulf are likely to increase the energy costs of the built capital required for extraction, thus reducing net EROI.

Finally, Miles and Morse (2007-this issue) look at the role of the mass media in natural disaster reporting and recovery. They show that natural capital received relatively less attention in the media coverage of recent natural disasters, especially hurricane Katrina. They apply an "elaboration likelihood model" (ELM) to argue that perceptions of risk due to natural hazards reflect the attention paid to each type of capital in current media coverage.

3. Conclusions

With high concentrations of natural, built, human and social capital, coastal zones play a critical role in sustaining human well-being, and the steady increases in damage from coastal disasters are therefore particularly threatening. Humanity's obsession with growth in the market economy as the sole measure of economic progress–in spite of growing evidence that continued economic growth does little to enhance human well-being–has disrupted the ecosystem services that ultimately sustain all of our capital assets, including the built capital responsible for economic growth. As Einstein is purported to have said, "We can't solve problems by using the same kind of thinking we used when we created them." If we are to protect our capital assets where they are most vulnerable, we must learn to view our economy as a complex and interconnected system comprised of all four types of capital which contribute in multiple ways to human well-being. We must recognize that in such a complex system striving to optimize a single type of value by using a single allocative mechanism is a recipe for disaster, coastal and otherwise. Coastal disasters are forcing us to recognize the interrelatedness of the different capitals and their valuable contributions to sustainable human well-being. Our goal is learn from these disasters how to sustainably, justly and efficiently allocate all four types of capital towards a high quality of life for all citizens. We hope that the articles in this volume contribute to this goal.

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