

natural resources often coincided with the emergence of new regional or global economic powers. If we are to understand the economic implications of the environment–development relationships in the emerging Age of Ecological Scarcity, then we should examine more closely how natural resource exploitation has influenced economic development in past historical periods.

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Achievements and future challenges for environment and development economics

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Addressing the challenge of ecological limits to economic growth and protection of the commons has been the central focus of scholarly research and policy debate in the world of EDE over the past two decades. Notable progress has been realized on a number of fronts but big challenges remain. Advances in the theory and practice of sustainable development, moving away from income measures such as GDP and promoting inclusive wealth as the right indicator of change in wellbeing and sustainability for the evaluation of economic performance and associated progress with the

development and use of natural resources and environmental accounts represent one major example. Another important example is the ecosystem services (ES) approach of the millennium ecosystem assessment that has now become the main framework widely adopted as the basis for the characterization, valuation and evaluation of tradeoffs among the multiple services of ecosystems impacted by the pursuit of economic growth. Together with progress in the science and economics of addressing climate change, these advances moved the EDE focus from micro- to macro-environmental economics management issues. Major manifestations of progress on these fronts include: the emphasis on the green economy for 'the future we want' at Rio+20 and the intended move beyond the millennium development goals (MDGs) to redirect future efforts of the international community towards new sustainable development goals (SDGs) and targets; global consensus and support for establishing an Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES); and efforts to better define planetary boundaries.

While the mentioned advances in EDE and related fields have led to a number of key international treaties and conventions primarily addressing protection of the global commons, parallel progress in sustainable management of the local commons still hugely lags behind. Major challenges continue, limiting progress in translating such global conventions and treaties into national and local policies, measures and regulations that are needed for effective interventions to protect the local commons where the impacts of economic activity are felt. Key challenging areas in this regard include the search for the appropriate institutional and policy models and the role of social capital in the protection and sustainable exploitation of local commons. Experiences with initiatives of scaling up and out the introduction of policy instruments such as schemes of payments for ecosystem services (PES) and rewarding the reduction of emissions from deforestation and degradation (REDD), for instance, while showing potential, have records of limited success due to major institutional and governance barriers at local and community levels.

One key remaining challenge for EDE is advancing the science and empirical methods of valuing the intangible services of ecosystems (i.e., the regulating and supporting ES underlying ecological composition, function and processes) and generating the data that is needed for monitoring changes in human wellbeing and ecosystems health metrics for evaluation of alternative courses of action and public choices. The economics of ecosystems and biodiversity (TEEB) initiative and the establishment and coordination of several global monitoring and data collection and processing networks such as the Global Earth Observation System of Systems (GEOSS) and the Global Terrestrial Observing System (GTOS) are major steps in this direction. Another major challenge that seriously limits our ability to evaluate the nature and size of future costs and benefits of increased consumption and economic growth relates to our current knowledge gap of and hence uncertainty about likely radical shifts in functioning ecosystems (e.g., non-convexities and catastrophic events). The high uncertainty about the socio-ecological future in turn increases the complexity of how to measure and discount the wellbeing of future generations over

distant time horizons. The biggest challenge of all for EDE is the persistence of high poverty and inequality in the distribution of inclusive wealth and human wellbeing in spite of the fast rates of economic growth and per capita consumption.

Environment and development: achievements and challenges in climate economics

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The economic analysis of the natural environment and of economic development encompasses most complex topics and issues. Accordingly, many contributions in the field are either cross-disciplinary or very detailed and broad in perspective. The core methodology of economics is different, however. Economic models are generally used to drastically reduce complexity and to look at a low number of analytical relationships. This allows for analysis of the basic mechanics of the problems in a concise manner and for the derivation of closed-form model solutions. There are of course seminal contributions using the procedure, e.g., [Hotelling \(1931\)](#) and [Dasgupta and Heal \(1974\)](#). But for the crucial issue of climate change the profession appears to be somewhat reluctant to push strongly for constructing a stringent analytical framework; the field is still dominated by relatively complex integrated assessment models. These yield many important insights but, in certain cases, provide contradicting results and sometimes lack intuition. Hence, climate economic models providing closed-form solutions on future growth and optimum climate policy appear to be warranted.

Climate change is a major topic in current environmental science but, at the same time, in development economics, because it will have a strong impact on the growth of less developed countries. In fact, the costs of global warming are severely biased against the less developed economies. The main reasons are significant differences in climate vulnerability and the internationally unequal availability of capital and knowledge for climate adaptation. Capital is a crucial factor for both growth and climate impacts. As an example, the 2010 floods in Pakistan damaged some of the most fertile agricultural grounds, causing losses of land, crops and cattle and destroying railway networks, roads, barrages, canals, villages, infrastructure and other essential facilities. The recent Typhoon Haiyan in