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Summaries

Soil degradation and economic development in Ghana

KNUT H. ALFSEN, TORSTEIN BYE, SOLVEIG GLOMSRØD and HENRIK WIIG

Soil degradation is among the most serious environmental problems facing many developing countries. The social cost of soil mining and erosion is frequently treated as an agricultural problem, but is actually affected by how the agricultural sectors interact with the rest of the economy. The article develops an integrated soil-productivity–general-equilibrium model for Ghana, and through several model simulations illustrate:

- the importance of soil mining and erosion for future economic growth in Ghana, and
- how various policies aimed at promoting growth in the agricultural sectors can affect overall economic performance in Ghana, influence the use of fertilizers and land, and provide incentives or disincentives for migration to and from the environmentally fragile Western region in Ghana.

The policy simulations underline the need for sheltering capital formation in the economy as a whole when stimulating higher productivity in the agricultural sectors. They also throw light on the problem of how to assess the cost of soil degradation in developing countries. Thus, if we ignore the two-way link between the economy and soil productivity, as is customary in conventional non-integrated forecasting procedures, we find that the annual GDP growth rate is overestimated by 0.6 percentage points compared with a fully integrated assessment. The reason is that in the integrated approach labour and fertilizer are substituted for less productive land to modify the cost of soil deterioration. If we take into account only the direct effects of soil degradation and ignore the substitution effects, the annual growth would apparently be lower by about 1 percentage point. These differences point to the importance of taking an integrated and economy-wide approach to soil degradation assessments.

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Wildlife, biodiversity and trade

EDWARD B. BARBIER and CARL-ERIK SCHULZ

The conservation of wild resources in developing countries is often portrayed as being in conflict with development activities such as agriculture, forestry and infrastructure investments that lead to the conversion of natural habitats. However, economic models of optimal exploitation of wild resources generally ignore this land-use allocation aspect of the problem and instead apply standard bioeconomic models of population dynamics and harvesting. Moreover, the role of wild-resource exploitation in international trade and the potential use of trade sanctions to enforce sustainable management of resources have been largely neglected, even though the threat of such sanctions for conservation purposes is on the increase. Finally, many of the wild species and resources contained in the natural areas of developing countries may have significant non-consumptive use and ecological values that could make an important contribution to overall welfare. Although generally non-marketed, these 'biodiversity' or 'stock externality' values are often significant and should be taken into account in allocation decisions affecting wild resources.

This article attempts to address some of these issues by developing a theoretical model of wild-resource exploitation that includes both the standard bioeconomic properties of growth and harvesting and a species–area relationship linked to habitat conversion. We also assume that the standing 'stock' of biological resources generates important ecological and non-consumptive use values. Defining $S(t)$ as the total stock or 'inventory' of biological resources (species), we suggest that changes in this stock are not determined solely by the aggregate biological growth rate across these species, but are also affected by the expansion in the number of species as the size of the natural area or habitat changes. As in a standard bioeconomic model, these changes in the total species stock, $S(t)$, must be net of any harvesting offtake. Finally, we account for any ecological or non-consumptive values by assuming that the stock $S(t)$ also affects welfare directly.

We explore the implications of this model for the long-run optimal stock of species held by the developing country. We do this first in the context of a closed-economy (without trade) model. There are two important outcomes. First, modifying the standard bioeconomic model to account for the costs of habitat conversion leads to a decrease in the equilibrium level of total species stock, i.e. $S_2^* < S_1^*$. In the modified model, changes in the total stock of biological resources are dependent not only on natural biological regeneration but also on total habitat area. However, holding land as natural habitat also implies an opportunity cost, which is represented by forgone consumption from development activities that use converted habitat land. Because conventional bioeconomic models do not take explicitly

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into account the opportunity cost of maintaining 'wild' lands as habitat for species, the equilibrium level of species stock—and thus implicitly habitat area—is higher than if the opportunity cost of maintaining habitat were included.

Second, we extend our closed-economy model to include the 'stock externality' or 'biodiversity' value of $S(t)$. If it turns out that this value in the long run is extremely high, then the equilibrium total species stock level may even exceed that of the standard bioeconomic model, i.e. $S^* > S_1^*$. However, whether S^* is less than, equals or exceeds the equilibrium species stock of the bioeconomic model, S_1^*, will depend crucially on whether the marginal value of biodiversity, U_S, is less than, equals or exceeds the marginal opportunity cost of maintaining natural habitat, $-U_c f'$. In Figure 1 we depict an equilibrium where $U_S < -U_c f'$ and thus $S^* < S_1^*$.

In the second half of the article, we develop our model to allow for trade. The basic assumption in this open-economy model is that some wildlife products are exported, which in turn allows the importation of consumption goods that can substitute for domestic production from converted habitat land. However, it is unclear whether the long-run equilibrium species stock under an open economy will be less than, equal to or greater than that under a closed economy. This ambiguous outcome derives from two counteracting influences of trade: exports of wildlife products mean more harvesting of wild resources, but imports reduce the reliance on domestic consumption from habitat conversion activities.

We also employ the open-economy model to examine the relative effectiveness of employing trade interventions as opposed to international transfers as means of inducing a developing country to conserve more of its total species stock in the long run. Under certain conditions, trade interventions may be unambiguously counterproductive, whereas the alternative policy of an international transfer of funds would lead to greater long-run conservation of species and habitat. Although in our model it is possible for trade interventions (trade bans, tariffs or trade subsidies) to have the desired effect of increasing long-run equilibrium species stock and habitat area, we need to know the specific conditions underlying the bioeconomic, habitat conversion and trade sectors of the model in order to determine the precise influence of trade policy interventions.

Hence, we conclude that trade in wildlife products may not necessarily lead to greater species and habitat conservation in a developing country, but once an open economy is established, trade intervention by the global community is a second-best approach for inducing the country to achieve further biodiversity conservation.

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Economic growth, energy demand and carbon dioxide emissions in India: 1990–2020

N.S. MURTHY, M. PANDA and J. PARIKH

This article investigates the linkages between economic growth, energy consumption and carbon dioxide (CO_2) emissions in India by analysing the structure of production and consumption in the Indian economy. Total energy supplies in India grew at an annual average rate of 3.2%, with commercial energy growing at even higher rate of 4.2–5.5% in different decades, during the period 1951–91. A large share of total commercial energy—about 85% of electricity, 70% of oil and gas and almost the entire amount of coal—is used for producing goods and services. In contrast to the developed countries where nearly 30% of total commercial energy is directly consumed by households, in India the figure is roughly 12%. A large percentage of households still rely to a large extent on non-commercial energy sources like fuelwood. CO_2 emissions from biomass burning are not included since they do not necessarily result in net emissions. Therefore, the current focus should be on achieving more efficient use of energy in the production sectors.

The CO_2 emission intensity of consumption expenditure in the urban areas is about 25% higher than in the rural areas, but does not vary much across different income classes in rural or in urban areas. Urbanization would therefore lead to a higher emission intensity for the Indian economy. The differences in per capita emissions across income classes are largely due to differences in income level and the rural/urban location factor. The results indicate that in 1990 the per capita CO_2 emissions of the bottom, middle and top classes in rural areas were 0.12, 0.16 and 0.27 tC respectively. The corresponding figures in urban areas are 0.17, 0.31 and 0.72 tC.

Energy consumption and CO_2 emissions for the year 2020 are projected under different technology scenarios. The projection methodology takes into account changes in the aggregate consumption pattern due to mobility of the population across the income classes and from rural to urban areas, besides the increase per capita consumption of all classes. The projection exercise shows that CO_2 emissions in India may rise from 149 million tC (mtC) in 1990 to about 812 mtC in 2020, an annual growth rate of 5.8%, in the business-as-usual scenario when it is assumed that there is no change in production technology. The per capita emission level correspondingly rises from 0.18 tC in 1990 to 0.62 tC in 22020. Per capita emissions in 2020 for the rural bottom, middle and top income classes are 0.33, 0.37 and 0.55 tC respectively, while for the urban areas they are 0.38, 0.54 and 1.15 tC. Obviously, such a no-technology-change scenario provides only

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an upper bound on total CO_2 emissions. However, when the energy efficiency for coal and electricity in all the production sectors and for petroleum products in the transport sectors is increased, the volume of CO_2 emissions in 2020 reduces to around 600 mtC, and the annual growth rate in CO_2 emissions at 4.8% is lower by 1%.

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