

## Summaries

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### **Technical progress and pollution abatement: an economic view of selected technologies and practices**

DENNIS ANDERSON

Technical progress has long been known to account for the major part of economic growth, but does it also hold the key to solving environmental problems arising from economic growth? Three sources of evidence suggest that it does:

- the historical experience of the industrial countries in addressing important categories of air and water pollution;
- comparisons between the developing and the industrial countries, which show that water and local air pollution levels are far lower in the latter, even though their economic outputs are far higher; and
- field studies of particular technologies and practices in place.

Even for the seemingly intractable problem of global warming options are emerging for the elimination of CO<sub>2</sub> emissions from energy production and use, for example through developments in a wide range of renewable energy technologies. By reference to the environmental and engineering literature on pollution abatement, the paper finds that technologies and management practices that can reduce pollution per unit of output by orders of magnitude exist in all areas of industry.

Furthermore, the costs, though sometimes large in absolute terms are low when measured in relation, say, to the costs of production or value added in an industry. In some instances they have proved to be negative, because unanticipated sources of efficiency were discovered, or because of significant side benefits. The technologies are also continually being developed and improved through environmental regulation and research and development (R&D) programmes in the industrial countries.

In all cases they are relevant for the situations in developing countries. If we consider some of the most pressing environmental problems in developing countries today – urban air pollution, the pollution of rivers and water supplies, acid deposition in Asia, and soil erosion – options have long been developed that could lead to these problems being substantially solved, at costs close to and sometimes below the damaging alternatives currently in use. Through simulation studies it is shown that with ‘good’ environmental policies in place there is no reason why they could not be introduced at a much earlier stage of development than was the case his-

torically in the industrial countries. The likelihood would be an increase not a decrease in the rate of economic growth and development in its broadest sense. The implications for environmental policies are discussed.

This conclusion could not diverge more from studies of the so-called environmental Kuznets curve (which the late Professor Kuznets himself never proposed) or the 'inverted U-shaped hypothesis'. These studies correlate pollution levels with per capita income across countries, and find that pollution rises with income, peaks and then declines only in the high-income countries. By their nature, they ignore the strides that have been made in the abatement of many forms of pollution – of air and water pollution in particular – in response to environmental problems in the industrial countries, and throw no light on the contribution of policy and technical progress to the possibilities for pollution abatement in developing countries.

## The environmental cost of water pollution in Chongqing, China

CHANG YONGGUAN, HANS MARTIN SEIP and HAAKON VENNEMO

Many large cities in the developing world experience serious pollution. This paper focuses on one such city and one form of pollution, water pollution in Chongqing, China. The question we raise is what does the damage done by water pollution amount to in economic terms? We find this question of interest since it allows us to indicate the magnitude and relative importance of various types of damages from water pollution. Knowing the magnitude and importance of damage from water pollution is helpful when assessing policy action to reduce water pollution and more generally the trade-off between economic growth and preserving the environment in developing countries. We illustrate to what extent costs of water pollution may be estimated in developing countries without large investments in terms of time and money.

It appears that water pollution harms our health and reduces outputs of agriculture, fishery, and industry. For example, we find in our study a much higher incidence of hepatitis and dysentery in areas polluted by water pollution than in comparatively 'clean' areas. Other researchers have found similar results. Moreover, we find that agricultural fields irrigated by wastewater and sewage consistently deliver significantly lower yields and lower quality crops with higher content of harmful substances. Water pollution kills off fish in the rivers and livestock and poultry along the riverbanks. Industry, which requires reasonably clean water, is held back by a lack of clean water supply.

All of these effects, and several more, are assessed, quantified and valued in our paper. In general we employ a conservative approach to quantification: In agriculture, fishery and industry the damage of water pollution equals the value of output and consumption lost. In health the cost of a disease equals the value of potential consumption lost when people cannot work or money is diverted into hospital expenses. We acknowledge that our approach to quantification could be criticized as a trivialization of the consequences of water pollution, yet the approach has proven to be a useful basis for policy formation previously. Starting from our estimate, policy makers and the interested public are of course free to add their subjective assessment of human suffering associated with disease, or the strain on ecosystems associated with damage to production.

We find the environmental cost of water pollution in 1995 to equal 1.2 per cent of Chongqing gross product. Based on a subjective estimate of uncertainty we find it likely that the true cost of the items we consider lies between 0.9 and 1.5 per cent. Output losses make up the largest share of costs. This finding is intimately tied to the way we value damages. One particularly difficult question is how to assess the fact that water pollution increases the risk of early death. Our main calculation assumes the so-called human capital approach to increased risk of death. When we use the willingness-to-pay approach, which is common in Western studies, the total cost increases to 4.3 per cent of gross product, and health damage makes up three fourths of the total.

## **Farm-level benefits to investments for mitigating land degradation: empirical evidence from Ethiopia**

BEKELE SHIFERAW and STEIN T. HOLDEN

In agriculture-based poor economies with fast-growing populations, degradation of land resources poses a threat to current and future food production potential. In an effort to mitigate the problem, a number of countries facing declining land productivity have initiated resource conservation efforts. However, soil and water conservation programs in the past have often fallen short of expectations. One basic problem has been that conservation programs are launched without evaluation of the net gains to small farmers from switching on to the new methods. The programs often start with external incentives to participating farmers, but land management resorts to pre-project conditions once intervention ends. Conservation incentives introduced without careful evaluation of farmers' short- and long-term costs and benefits may also provide perverse incen-

tives to farmers, which tend to escalate resource degradation. If private incentives exist for implementing conservation programs, external incentives should not be used. If farmers fail to adopt economically viable technologies, an appropriate policy response is to identify and rectify existing constraints (e.g. credit access, land tenure, etc.). Evaluation of costs and benefits of conservation investments is a necessary first step to understanding economic constraints to small farmers and formulating suitable policies for sustainable land management.

Analysis of some of the existing empirical evidence from Ethiopia indicates that economic gains to small farmers from implementing new structural conservation methods under the existing production and institutional setup are minimal. Only investments in low-cost vegetative methods (grass strips) seemed to provide sufficient economic incentives to small farmers. The low returns to conservation options were mainly due to the reduction in the effective area planted, high initial investment costs, and their limited efficiency to mitigate soil erosion. Combined with the already low yields of crops grown on shallow soils, production tends to become unprofitable as soils are depleted quickly before conservation investments are paid back. Compensating the effect of area loss through proper utilization of the land occupied by the structures improves returns to some conservation measures, but the economic incentive diminishes when future benefits are highly discounted.

This suggests that based on evaluation of private returns to conservation investments, most of the existing conservation technologies are unattractive to small farmers especially when conservation introduces a yield penalty due to area loss. If adoption is promoted through coercion and minimal external incentives as in the past, farmers are likely to revert to old methods once intervention ceases. Policy options to counter degradation of agricultural lands in the Ethiopian highlands should consider new ways for offsetting the area loss effect through proper use of the land taken up by structures and supporting the initial investment costs of soil conservation. Short-term policies should also focus on the development and dissemination of low-cost vegetative methods (like grass strips), which offer both conservation and economic benefits to smallholders. Farm-level benefits to conservation are higher on degrading soils where the marginal effect of soil erosion is high than on highly degraded soils where yields have already reached very low levels. Conservation incentives are also low where current yields are high and the marginal effect of soil erosion on crop yields is small. This indicates that the benefits to investments in proposed structural conservation methods are low on very deep soils where crop yields are high and the cost of soil erosion is low, and on very shallow soils where crop yields are very low and conservation benefits are short-lived. Soil conservation is unlikely to be economically attractive on highly degraded soils where low-value food crops are grown unless new approaches for rehabilitating such lands through shifting to high value and less-erosive tree crops are considered. Conservation efforts may, therefore, need to concentrate on highly degrading soils before the soil quality is severely depleted.

## **Synergies between livestock production and hydrological function in Arenal, Costa Rica**

BRUCE AYLWARD and JAIME ECHEVERRÍA

Conventional wisdom holds that the conversion of tropical rainforest to pasture leads to a rapid loss of soil fertility, a rise in the sedimentation of waterways and reservoirs, an increasing in flooding, and a decrease in dry season water supply. As a consequence, the establishment of large hydroelectric reservoirs in deforested watersheds often leads to proposals for curtailing agriculture and livestock production in favor of watershed protection and reforestation.

The Río Chiquito watershed in Costa Rica supplies water to Lake Arenal and a hydroelectric scheme that supplies 30 per cent of the country's electricity. Over half the watershed is devoted to livestock and dairy production, with the remainder covered in cloud and premontane forest. Economic analysis of ranching and dairy production reveals that, while some small producers are border line profitable in economic terms, larger producers are generating significant returns to land in Río Chiquito (average returns per holding in net present value terms of \$500/ha). Meanwhile, available evidence fails to convincingly demonstrate that pasture use is leading to rapid and pervasive loss of soil productivity in the volcanic Arenal soils.

Analysis of hydrological function suggests increases in sedimentation for pasture areas and large gains in water yield from pasture in non-cloud forest areas. In the upper watershed area of Río Chiquito, the very 'patchy' cloud forest landscape will lead to an increase in the capture of fog moisture above that in either pasture or forest alone. In physical terms, the increased volume of water yield that can be expected from pasture in Río Chiquito is one to two orders of magnitude greater than the corresponding increase in sediment. Productivity of the downstream hydroelectric scheme is lowered by an increase in sediment, but raised by the increase in water yield. Netting out the economic impact on power generation suggests that reforestation would lead to large losses in power generation, in the range of from \$250 to \$1,100 per hectare. Sensitivity analysis suggests that even if livestock production were to reduce infiltration rates so that all of the gain in water yield accumulated in the wet season (instead of being spread across dry and wet seasons), the magnitudes for these externalities would not change greatly.

As non-hydrological externalities are likely to be of minimal importance in Río Chiquito, the study suggests that watershed management efforts should focus on how to maximize the complementary returns from livestock and water production. It must be emphasized that the analysis of these relationships is site specific and that the particular results of this study should not be applied, or transferred, to other areas. Rather the paper seeks to highlight the need to revisit the conventional wisdom regarding land use–hydrology interactions and to estimate the changes in

economic productivity associated with alternative land use choices and their downstream hydrological impacts. This is of particular importance in the case where resources, such as donor funds or government incentives, are to be invested in reforestation watersheds that feed large hydroelectric reservoirs in the humid tropics.

## **Environmental impacts and mitigation costs associated with cloth and leather exports from Pakistan**

SHAHRUKH RAFI KHAN, MAHMOOD A. KHWAJA and ABDUL MATIN KHAN

One of the important propositions of the trade and environment literature is that exports will generate a great deal of pollution in poor countries because of the environmentally unsound production methods they utilize. Another proposition in this literature is that the costs of reducing such pollution in poor countries are very high. We explored both these propositions using data from cloth production and leather tanning, two of Pakistan's strategically most important but very dirty production processes.

We forecasted the increase of exports of cloth and leather and footwear for Pakistan, based on past trends and work done by others, that could result from the reduction in trade barriers agreed to in the Uruguay Round trade talks in 1994. Between 1996 and end 2004, cloth exports for Pakistan can be expected to rise by 45 per cent and the corresponding increase in pollution load is calculated to be 81 per cent. Leather exports are expected to decline, so one could expect a 7 per cent lower pollution load generated by leather tanning, as things stand. If suggested measures are adopted to reduce the pollution, up to 91 per cent of the emissions from cloth and 66 per cent of the emissions from tanning could be reduced.

The costs of such measures in cloth production, for the economy as a whole, would have been 12 per cent of GNP in 1996. The foreign exchange liability, in terms of imported equipment, for this year would have amounted to 1.6 per cent of only cloth exports in 1996. More important, the cost to industrialists for adopting measures to reduce pollution would have been 1.6 per cent of their sales revenue. The costs of such measures in leather production, for the economy as a whole, would have been 0.0048 per cent of GDP and the mitigation cost to exporters of leather would have been 0.88 per cent of their export revenue. These mitigation costs are much lower than for cloth production since clean production technology is locally available.

Thus, the evidence from our case studies supports the first proposition that export growth may generate a great deal of pollution. However, there

is little support for the second proposition that the costs of establishing and operating clean technology in the South are necessarily very high. Also, a rough calculation of the benefits indicate that these are 0.5 per cent and 0.04 per cent of GDP for textile and clothing and leather respectively and that these far exceed the costs. Admittedly, our estimates are crude, but the benefits exceed the costs by such a large margin that it is unlikely that refinements would change the main message that, from society's perspective, it would pay to encourage the adoption of standards for reducing pollution.

Adopting environmental standards represents a win-win strategy for the whole economy due to the reduction of environment-related health care costs, the loss of productivity and jobs, and the potential gain in export markets. It also represents a win-win situation for the individual industrial unit because adopting environment management systems can enhance efficiency, resource saving via recycling, resource recovery and improved waste management and energy conservation among other benefits.