# Modeling for environment policy in India

Ashish Rana and Toshihiko Masui
*National Institute for Environmental Studies, Japan*

## Abstract

Environmental pollution in India, as in the rest of the world, is increasingly becoming an important issue. Despite the regulations in place the enforcement has been weak. Government policies, in addition to regulatory mechanisms, incorporate a few market based economic instruments in economic and environmental planning. However, there is little integration in the present set of economic and environmental policies in India. A need to assess integrated policies is strongly felt. In this paper, we employ a Computable General Equilibrium (CGE) model. This CGE model includes material flows along with integration of economic sectors with pollutant management activities, particularly solid waste management. Scenarios with environmental constraints and with enhanced environmental investments are constructed and compared with the reference scenario, which does not have any environmental constraints. Preliminary results indicate that the economic growth is affected when constraints, such as limit on emissions or final waste disposal, are imposed but with enhanced environmental investment these losses are mitigated.

## 1 Introduction

Environmental degradation is pervasive in India and as in the rest of the world it is becoming increasingly important issue for policymakers in India. The main environmental problems in India relate to air and water pollution, solid waste disposal, degradation of common property resources, threat to biological diversity, and sanitation. Increasing deforestation, rapid industrialization and urbanization, increased transportation and input-intensive agriculture are some of

the major causes of environmental problems being faced by the country. Poverty presents special problems for a heavily populated country with limited resources.

Besides the domestic problems, the concerns for controlling greenhouse gases like $CO_2$ are also increasingly becoming too important to ignore. India is a signatory to the United Nations Framework Convention of Climate Change (UNFCCC). Recently concluded Marrakech Accord has paved a way for ratification of Kyoto Protocol by Annex B countries of the Protocol. In this context India is preparing its strategies for responding to the needs of the global climate change regime.

Awareness about the environmental problems is high but still in most parts the present policies are not able to tackle them. Present regulations, such as The Environmental (Protection) Act, 1986, give the Central Pollution Control Board, and its State-level counterparts, broad powers to control the problem of air pollution, water pollution and solid waste, the enforcement has been weak. Government policies, in addition to regulatory mechanisms, incorporate a few market based economic instruments in economic and environmental planning. It is increasingly being felt among the policy makers that there is an urgent need to reconcile economic growth and environmental conservation. Policies that help in reducing environment degradation while at the same time increasing growth in the critical sectors of the economy are strongly needed. In addition, the need to address global climate change brings in another dimension for policy formulation.

A computable general equilibrium (CGE) model developed specifically to assess the policy integration of climate change and waste management is employed in this study. Quantitative models have been recognized as important tools to understand relative effectiveness of policies. For environment policy also many models have been built and are found in literature. The modeling approach in each of these depends on specific purpose of model. Broadly, linear programming, input-output, and computable general equilibrium models are predominant approaches. Among these, CGE approach has many appealing features which are not present in others like endogenous determination of prices by simultaneous clearing of many markets based on Walrasian general-equilibrium theory.

For India, while there is substantial use of models for analyzing long-term effects on energy system due to climate change policies ([1],[2],[3],[4]), there is lack of models that assess policy for the short-term local environmental problems simultaneously with strategies for global regimes. In this respect the current study fills that gap.

## 2 Model description

AIM/Material model ([5],[6]) is the country based computable general equilibrium model applied for the present analysis of India. The salient feature of this model is that it includes material flows along with integration of economic sectors with pollutant management activities. Figure 1 shows the structure of AIM/Material.

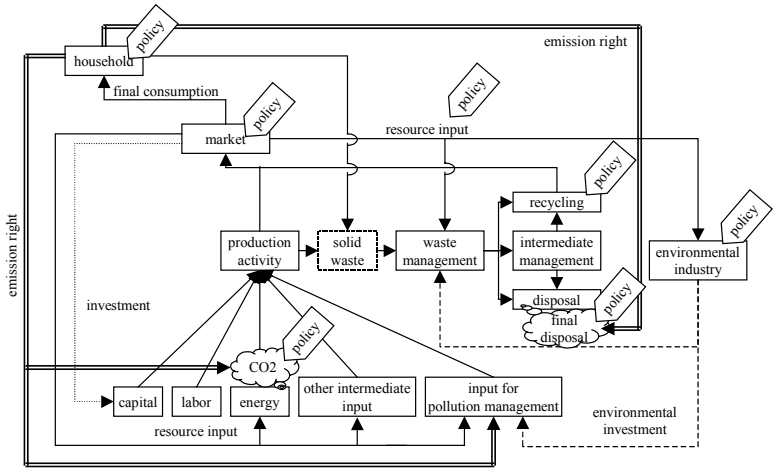


Figure 1: Model structure

The base year for Indian model is 1994, and the model is calculated year by year until 2010. That is to say, the dynamics are recursive. Not only the ordinary economic activity but also the solid waste management is treated. The solid waste is generated through the economic activities. The present version of the model has 26 sectors and 24 commodities as shown in Table 1.

Table 1: Sectors in the model

| Short Name | Full Name | Short Name | Full Name |
|---|---|---|---|
| AGR | Agriculture | WTR | Water supply |
| MIN | Mining | SRV | Services |
| FOD | Food | MWM | Municipal Waste Management |
| TEX | Textiles | IWM | Industrial Waste Management |
| PLP | Paper and Pulp | EMC | Environmental Capital Goods |
| CHM | Chemical | GOV | Government |
| NMM | Non-metallic Minerals | COL | Coal |
| BMT | Basic Metals | OIL | Oil |
| FMT | Fabricated Metals | GAS | Gas |
| MCH | Machinery | ELE | Electricity (only commodity) |
| ELM | Electrical Machinery | HYD | Hydroelectricity (only sector) |
| TRE | Transport Equipment | THE | Thermal electricity (only sector) |
| OTH | Other Industries | NUC | Nuclear electricity (only sector) |
| CNS | Construction | | |

Each production sector maximizes its profit, and household sector maximizes the utility under the income constraint. In this model, the markets of

produced goods and production factors exist, and all the markets are in equilibrium. Solid waste is categorized into 14 types as shown in Table 2.

Table 2: Categories of Solid Waste

| Short Name | Full Name |
|---|---|
| ASH | Ash |
| SLD | Sludge |
| WOL | Waste Oil |
| WPL * | Waste Plastic |
| WPP * | Waste Paper |
| WWD * | Waste Wood |
| WTX * | Waste Textile |
| WAP * | Animal and Plant Waste |
| SCM * | Scrap Metal |
| WGC * | Waste Glass |
| SLG | Slag |
| WCT | Construction Waste |
| DST | Dust |
| WZZ | Other waste |

Note: * categories of municipal waste

In order to produce economic goods, capital, labor, energy, other intermediate inputs, and pollutants are required. The pollutant as the input factor has three functions. The first is that of an input like capital and labor in order to treat the pollutant generated from the production process. The second is the purchase of the pollution treatment service from sewage sector, solid waste management sector, and so on instead of self treatment. The third is the purchase of the emission rights. The emission right means that the each economic sector must buy the emission right in case of discharging pollutants. At present, the price of the emission right is assumed to be 0, because the quantity of supply of the emission right is much more than the demand. In the following analysis, the emission rights on the CO2 emissions and final disposal of solid waste are taken. If the demand of emission right exceeds the supply, the price will be generated. This price can be regarded as the tax on this environment. By the pollutant as the input factor, it can be interpreted that some of the generated pollutant are managed in the self management sector, and some of them are discharged into the environment. The solid wastes and sewage can be managed in solid waste management sector and sewage sector, respectively.

The solid wastes are disaggregated into the industrial wastes and the municipal wastes. The industrial wastes are defined as the wastes generated from the production process, and the municipal wastes are defined as the wastes from residential and commercial activities. Each generated waste is treated in the process of direct reuse, direct final disposal, or intermediate management. The residuals of the intermediate management is reused or disposal. Total reused wastes are supplied to the market as the recycled material. At present, the recycled wastes are used as the intermediate inputs in the specific production sectors. For example, “ash” is used in the construction sector, ceramic, stone and

clay products sector and so on as the substitution of mining products such as sediment.

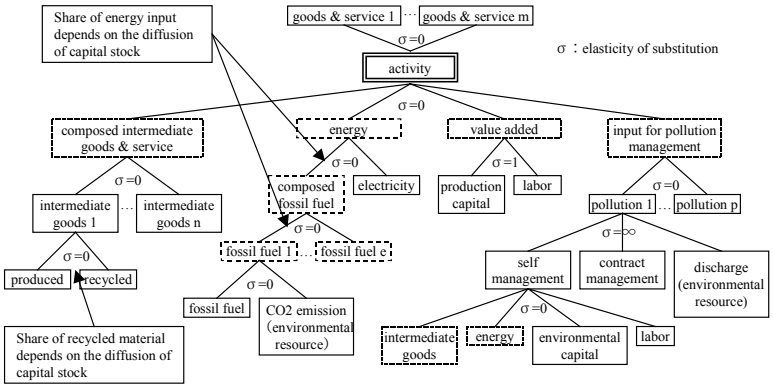


Figure 2: Production structure

Figure 2 shows the structure of production activity. In order to keep the equilibrium of both economic balance and material balance in production activity, the number of elasticity of substitution between the recycled material and the competitive economic goods is defined as 0. This means that the share of recycled material input is decided from the settled capital, and the additional investment is necessary for enhancement of the recycled material inputs. According to the energy inputs, the elasticity of substitution among energies is defined as 0, too. Although the energy input share is fixed in advance, this share is changed by the introduction of new equipment. The reason of this assumption is that the time step of this model is one year. From the viewpoint of short term such as one year, the substitution of energy input and recycled waste does not occur if the equipment is not changed. Moreover, the indices of technology improvement such as energy efficiency improvement and waste management efficiency are also calculated by taking into account the vintage of capital. The information on the technology improvement can be introduced from the results of the bottom-up model treating the each technology device, although in this analysis this indicator is introduced as the scenario. Figure 3 shows the flow of model simulation.

## 3 Data

This model requires two main classes of data - the economic data and data on waste generation. While economic data is published by the government and other reliable sources and is easily available, data on waste generation from industries is scarcely available in the form required by the model.

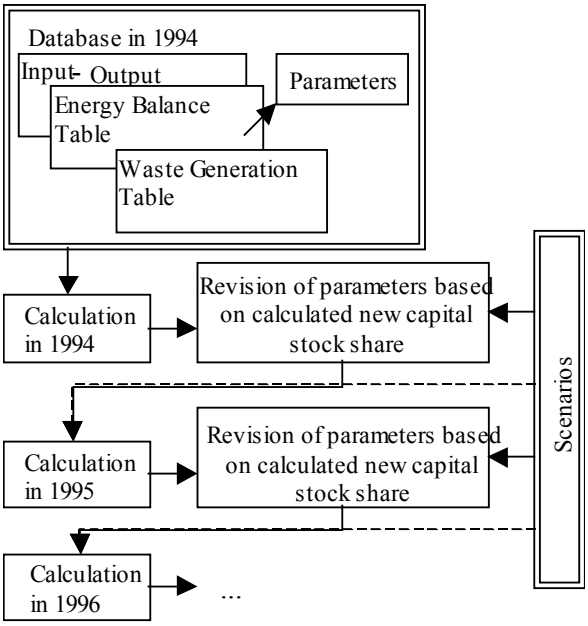


Figure 3: Flow of simulation

Input-Output tables for 1993-94 from the Central Statistical Organization (CSO), Government of India, are central to the model [7]. However, as with most other countries, the environment industry does not figure in the national industrial classification of India. This sector is worked out from the estimate of total output of environment industry in India and overlaps of this industry with other industries such as machinery, fabricated metals, electrical equipments, chemicals, construction, and services. Energy data was taken from TEDDY 2000-2001 [8].

For estimation of waste generation from industries, reports from Central Pollution Control Board (CPCB) [9] were utilized. CPCB is the regulatory authority responsible for monitoring pollution from industries and enforcement of relevant environmental laws in India. It collects information on various industries and publishes comprehensive industry documents. Estimate of different types of wastes generated from a typical process in a given industry are available from these reports. These are often given in physical terms such as sludge generated per ton of output of the industry. The amount of ash generated in each industry was estimated from total self-generation of thermal power in the industries.

The data on municipal waste generated in India is taken from the report of Planning Commission of India [10]. The report gives an account of municipal solid waste generated in major cities of India and also the composition of waste.

Assumptions are required for the growth of capital and labor productivity, autonomous energy efficiency in industry and households, growth in waste generation and disposal. These assumptions are taken on the basis of other studies and reports.

## 4 Scenarios

For undertaking the analyses of policy effects we build counterfactual scenarios to reflect the changes in policy. In this paper we present some results from following three scenarios.

Scenario 1 – reference case with no constraints on emissions or waste disposal

Scenario 2 – with restricted final disposal of solid waste

Scenario 3 – with enhanced environmental investment

There are no constraints or given targets for CO2 emissions in India at present but the Municipal Solid Waste Management Rules 2000 state that land filling shall be restricted and investments should be made to make use of wastes so as to minimize burden on landfill. As to the question about how much to limit, there are no quantitative guidelines given in the above-mentioned Rules. However it is perceived that landfill activity in India will come under close watch in future and reckless dumping of wastes will be checked. Therefore the constraints scenario – Scenario 2 - is constructed with limits on availability of landfill site for disposal of waste. It is assumed that the availability of landfill sites will be decreasing in a phased manner.

In Scenario 3, enhanced investments for environmental preservation activities are assumed. Environmental industry in India, both domestic and imports, is in growth stage. Size of environmental market in India is currently estimated at around $2 billion and is forecast to increase to about $7 billion by 2010 [11]. Between 1995 and 1999, imports from US alone have grown by about 5% [12]. However, it is clear that much of mitigation can be achieved with low marginal cost by improvement in waste management systems, improvement in organization efficiency and other low-tech measures such as segregation of waste. Requirement of costly advanced technology for pollution prevention in many of the sectors would not be high in the short-term horizon.

## 5 Preliminary results

In Scenario 1, the reference scenario, GDP is projected to increase at a rate of 5.6 percent per year from 1994 to 2010. CO2 emissions in this period increase at 4 percent per year. Since there are no constraints on waste disposal, the waste management sectors grow at a rate lower than the overall GDP growth.

Changes in GDP, CO2 emissions and waste disposal in Scenario 2 and Scenario 3 over Scenario 1 are shown in Table 3. In Scenario 2, waste disposal is reduced by 50 million ton in 2010 while the cut in emission is about 3 MtC and the overall reduction of GDP is about Rs.50 billion representing a 0.25 percent loss over the reference scenario.

In Scenario 3, countermeasures for environmental preservation result in overall improvement in the economy with GDP gaining slightly. Intuitively, increase in environmental investment will boost use of technology for reducing pollution load from industry and the available landfill sites can intake more quantity of waste thus releasing constraint on them and consequently mitigation of economic loss. Emissions and waste disposal in Scenario 3 are lower than the reference case. This is a case of double dividend because on one hand there is gain in GDP and on the other hand there would be benefits such as reduced damage to health due to lower environmental pollution. Furthermore, this is also a case for integrated policy for waste as well as emissions. Although we do not include a constraint or countermeasures for CO2 there is a change in emissions as a result of enhancement of environmental industry.

Table 3: Changes in GDP, CO2 emissions and waste disposal over Scenario 1

| | GDP (Rs. Billion) | | CO2 (MtC) | | Waste Disposal (Million ton) | |
|---|---|---|---|---|---|---|
| | Scen2 | Scen3 | Scen2 | Scen3 | Scen2 | Scen3 |
| 2000 | -12.39 | -12.39 | -1.34 | -1.34 | -32.55 | -32.55 |
| 2001 | -16.75 | -16.75 | -1.36 | -1.36 | -27.33 | -27.33 |
| 2002 | -21.97 | -21.97 | -1.40 | -1.40 | -23.09 | -23.09 |
| 2003 | -28.45 | -28.45 | -1.43 | -1.43 | -17.59 | -17.59 |
| 2004 | -30.48 | -32.76 | -1.56 | -1.50 | -21.29 | -16.02 |
| 2005 | -31.63 | -35.70 | -1.72 | -1.59 | -24.83 | -13.94 |
| 2006 | -36.67 | -5.31 | -1.89 | -1.45 | -27.83 | -10.92 |
| 2007 | -38.84 | -2.33 | -2.11 | -1.53 | -33.61 | -10.27 |
| 2008 | -42.01 | 0.61 | -2.35 | -1.62 | -39.47 | -9.27 |
| 2009 | -46.12 | 3.58 | -2.62 | -1.72 | -45.42 | -7.90 |
| 2010 | -50.28 | 7.26 | -2.91 | -1.82 | -51.45 | -6.13 |

Figure 4 shows simulation results of GDP change for a few selected sectors to highlight the point that in Scenario 3 there is recovery in sectors that faced losses under the constraint scenario.

In Scenario 2, the industrial waste management sector, IWM, will increase even though the economic activities will reduce by the environmental constraints. This represents that the constraint on the final disposal of solid wastes enhances the value added of waste management. Industrial waste management sector activity increases almost ten times over the fifteen-year period in the constraint scenario. With countermeasures the requirement for such increased level of activity of industrial waste management is dissipated as investments for waste management within sectors are undertaken to release the constraint on final disposal of waste.

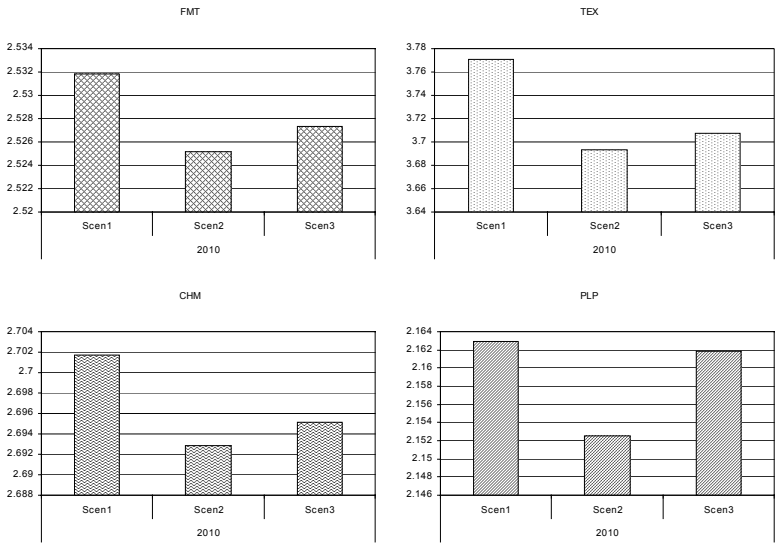


Figure 4: GDP Changes in Sectors (1990 = 1)

## 6 Conclusion

This paper presents the application of a computable general equilibrium model for analysis of environment policy. The salient feature of this model is that it includes material flows along with integration of economic sectors with pollutant management activities.

Selected results presented in this paper are preliminary but they provide many important observations. While the constraint scenario shows deep reductions in waste disposal as well as emissions, it is accompanied with overall economic loss. This implies that industry should act in a wise manner so as to contain wastes from production and hence economic loss. One of the options that could avoid such loss is investment in environmental industry. The model results indicate that GDP losses are recovered by such investments therefore this could possibly be the ‘double dividend’ option.

Availability of sites for waste disposal cannot be taken for granted anymore in developing countries like India. Conscious efforts are required to mitigate the losses due to environmental constraints. These efforts have to come both from policymakers as well as industry. Policymakers have to give clear signals that strict regime of environmental laws is going to be enforced with incentives for investments in technology for preservation of environment. This will boost confidence among the domestic industry to make those investments.

Further work is required for refining our simulation results. We should also look at alternative options such as enhanced recycling. Recycling activities are traditionally undertaken widely in India but mostly through the informal sector. It is extremely difficult to include these since quantitative estimates of waste recycling are not available. Nevertheless anecdotal evidence from literature indicates that recycling in its present and enhanced form can also prove to be a successful option for achieving environmental goals.

## References


[1] Shukla, P.R., The Modeling of Policy Options for Greenhouse Gas Mitigation in India. *AMBIO*, Vol. XXV, No. 4, June, pp. 240-248, 1996.

[2] Rana, A. & Shukla, P.R., Macroeconomic Models for Long-term Energy and Emissions in India. *OPSEARCH* (Special Issue on Energy and Environment Modelling), Vol. 38, No. 1, February, pp. 87-108, 2001.

[3] Garg, A., Ghosh, D. & Shukla, P.R., Integrated Modeling System for Energy and Environment Policies. *OPSEARCH* (Special Issue on Energy and Environment Modelling), Vol. 38, No. 1, February, 2001.

[4] Shukla, P.R., Nair, R. & Rana, A., Integrated Modeling and Analysis of Long-term energy and emissions trajectories for India. *Paper presented at International Workshop on Climate Policy in Asia organized by Institute for Global Environmental Strategies* at Tokyo, Japan, December 17-18, 2001.

[5] Masui, T., Matsuoka, Y. & Morita, T., Development of Applied General Equilibrium Model Integrated Environment and Economy (in Japanese), *Environmental Systems Research*, **28**, pp. 467-475, 2000.

[6] Masui, T., Quantitative analysis on economic effects of environmental policies under environmental constraints using computable general equilibrium model. *Presented at IFAC Workshop on Modelling and Control In Environmental Issues*, Yokohama, Japan, August 22-23, 2001.

[7] Central Statistical Organisation (CSO), *Input Output Tables 1993-94*. CSO, 2000.

[8] Tata Energy Research Institute, TERI Energy Data Directory and Yearbook (TEDDY) 2000-2001. Tata Energy Research Institute, 2001.

[9] Central Pollution Control Board (CPCB), Comprehensive Industry Documents, Various issues.

[10] Planning Commission, Urban Solid Waste Management in India. *Report of High Power Committee*. Government of India, 1995.

[11] CII, Environment Market in India. *Internet document: http://www.cleantech-india.com/ environmentmark.pdf*

[12] United States – Asia Environmental Partnership (US-AEP), *U.S. Environmental Industry Export Competitiveness in Asia.* US-AEP, 2001.