COMPUTER MODELLING OF ENERGY AND ENVIRONMENT: THE CASE OF BANGLADESH

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ABSTRACT

This paper examines the modelling efforts on energy and environment and presents the projections of energy supply and demand and assesses the contributions to global warming. The output of a system dynamics model is fed into the LEAP model and overall energy balances are then compiled using a bottom-up approach. Simulated results show that the major share of energy is from biomass and that of commercial fuel is from natural gas. Simulated results also show that there is a tremendous pressure on rural forests for fuelwood. As the result, there is overcutting of rural forests resulting in environmental degradation. Bangladesh is responsible for a small fraction of the total anthropogenic contribution of CO_2 but could be seriously affected by climatic change. Energy planning for sustainable development with LEAP is made more effective by using a complementary system dynamics model.

INTRODUCTION

Energy is needed to meet subsistence requirements, as well as demands for economic growth and development. Per capita consumption of energy is a measure of the physical quality of life and it is low in Bangladesh. The energy situation in Bangladesh is complex because of the lack of resources, a large population density and heavy consumption of biomass fuels(crop and animal wastes, fuelwood). These are being rapidly exhausted. Hence, biomass deserves special attention in energy planning for Bangladesh.

Emissions of greenhouse gases from energy production and use contribute to global climatic change through increase in surface temperature. Although the timing and magnitude of such temperature changes are uncertain, the potential impacts include sea level rise, decreased rainfall in the agricultural regions, and increased violence of tropical storms. In this study, we demonstrate the potential of LEAP(Long-range Energy Alternatives Planning) with proper data inputs as a tool for planning for sustainable development in Bangladesh.

COMPUTER MODELLING

Huq (1975) initiated rural energy modelling in Bangladesh. The model proposed by Huq was further developed for integrated rural energy system in Bangladesh using a system dynamics approach (Bala and Satter 1986, Alam et al 1990). Nail (192) reported a real success story for a system-dynamics model for national energy policy planning; this model was also employed to address the effects of energy use on global warming (Nail et al 1992). Bala (1997) presented projections of rural energy supply and demand and assessed the conributions to global warming for Bangladesh using LEAP.

Energy and environment model projects production, consumption, imports and addresses the effects of energy use on global warming. Fig.1 shows the basic interactions between energy production and supply including the effects of energy use on global warming. In the demand sector, energy consumers make decisions to utilize gas, oil and electricity based on both fuel price and the availability of the fuels whereas the biomass fuel consumption is mainly based on the availability of the biomass fuels. Three major supply for commercial fuels are natural gas, oil and electricity while three major supply sectors for biomass fuels are firewood, agricultural wastes and animal wastes.

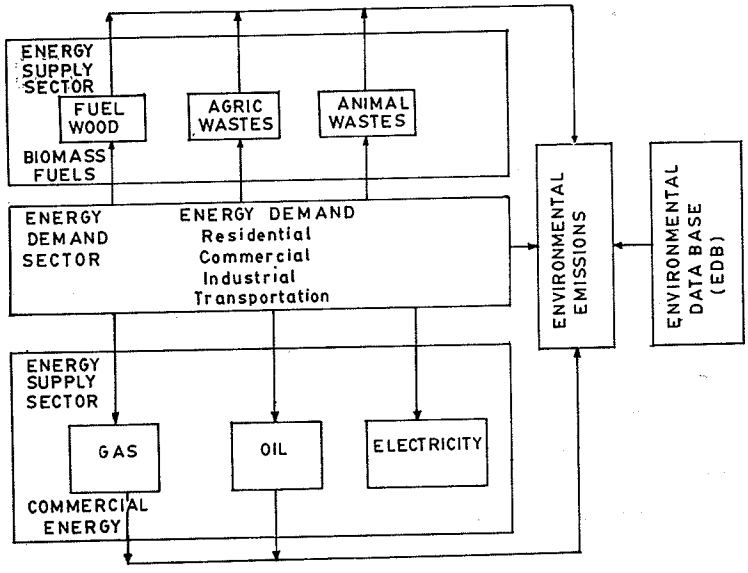

Fig.1 Overall Structure of Energy and Environment Model.

System dynamics models projects population, cowdung and agricultural wastes and these data are fed into the LEAP model.The overall balances of energy system in Bangladesh are compiled using a bottom-up approach in the LEAP model.

RESULTS AND DISCUSSIONS

Energy Scenarios

Computer projections of energy demand by fuel type are shown in Fig.2. The major share of energy is from biomass and that of commercial energy is from natural gas. The biomass fuels are mainly used for cooking but are used inefficiently (η <10%). Energy demands for agriculture (cultivation and irrigation) are increasing because of modernization of agriculture for increased production. Conservative estimates based on computer simulation show tremendous pressure on the rural forests for fuelwood, which results in overcutting of rural forests.

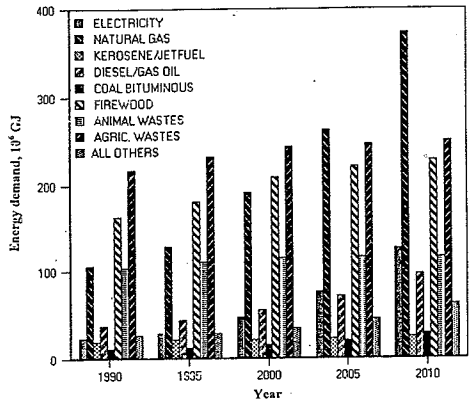

Fig.2. Energy demand by fuel type in Bangladesh.

Environmental Effects

Emissions of greenhouse gases for energy consumption in Bangladesh are shown in Table-1. This contribution is small in the global context. Non-sustainable harvesting of biomass contributes to environmental degradation. As a result, the relative humudity of air decreases and desertification starts. The westernpart of Bangladesh is already under such a threat due to ecological imbalancecreated as a result of clearing rural forests for fuelwood.

Table-1 Environmental effects

Air emissions, tonnes	year 1990	year 1995	year 2000	year 2005	year 2010
Carbon dioxide (10^6)					
Non-Biogenic	12.19	14.88	20.52	26.70	36.06
Biogenic	49.11	52.95	57.33	59.12	60.36
Carbon Monoxide (10^3)					
Total	4139.31	4465.65	4826.05	4957.70	5036.75
Hydrocarbons (10^3)					
Total	55.80	62.38	73.12	81.71	91.66
Methane	122.53	138.14	183.58	252.67	358.14
Nitrogen Oxides (10^3)					
Total	133.79	159.84	220.16	275.42	348.86
Sulfur Oxides					
Total ($10^{3)}$	67.93	73.24	78.06	79.86	81.46
Sulfur Dioxide	3696.1	4047.19	4579.58	4642.06	4425.04
Particulates					
Total (10^3)	957.67	1025.60	1085.16	1098.73	1100.93

CONCLUSIONS

Simulated results show that the major share of energy is from biomass and that of commercial fuel is from natural gas. Bangladesh contributes a very small amount of CO_2 on a per capita basis but could be seriously affected by climate change. LEAP in combination with a system-dynamics model is more effective than LEAP alone for energy and environmental planning for sustainable development.

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