REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE II)

TATA ENERGY RESEARCH INSTITUTE
NEW DELHI

REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE II)

Submitted to the
International Development Research Centre, Canada

Tata Energy Research Institute
New Delhi

Contents

A REAPPRAISAL OF WRI'S ESTIMATES OF GREENHOUSE GAS EMISSIONS

Dr. R.K. Pachauri
Ms. Sujata Gupta
Ms. Meeta Keswani

In the current debate on global warming and climate change and strategies and measures to stabilise the earth's atmosphere, estimates of emissions in the past and future projections would provide critical information for forthcoming negotiations. Any convention to limit the emissions of greenhouse gases (GHGs) would also use as a starting point the quantification of past and future emissions. It is, therefore, necessary that the developing countries carry out detailed analyses of their emission levels and ensure that accurate and unbiased information is disseminated to mobilise worldwide public opinion in support of equity issues of relevance to the third world.

The World Resources Institute(WRI) in its recent report "World Resources, 1990-91" has directed considerable attention to this topic. By providing estimates of emissions of GHGs it has identified the 50 largest contributors to global warming. Although the WRI report is being widely publicised and frequently quoted, the numbers contained in this study ought to be treated with great caution.

The approach adopted by the WRI in calculating the "Greenhouse Index", by which different nations are ranked, is highly questionable. It is a scientifically established fact that the heating potential of a gas depends not only on its radiative forcing (the capacity of the gas to absorb heat within a particular wavelength range) but also its residence time. For example, in the case of two gases with the same radiative forcing but with different lifetimes, the gas with

a longer life will have a greater potential to cause warming, because it would be active for a longer duration. Recognising this fact, the Inter-governmental Panel on Climate Change (IPCC) has arrived at the global warming potential(GWP) for different GHGs by taking the decay function of carbon dioxide (CO_2) and radiative forcing over a period of hundred years as the numeraire (integration time horizon = 100 years).

The WRI report has ignored the residence time of different gases, thereby giving gases like methane (CH_4), with a high radiative forcing but a shorter lifetime, an unduly high relative GWP compared to CO_2. Hence, their ranking is unacceptable, as it is biased against the developing countries, which are normally low emitters of CO_2 as opposed to the industrialised nations. In this note an attempt has been made to correct this inconsistency inherent in the WRI estimates.

Furthermore, the data for India on CH_4 emissions from paddy fields (wet rice) and for CO_2 emissions from deforestation are grossly overstated. These numbers are also rectified in this note.

In making our calculations, the following assumptions made by WRI are maintained as they are based on factual measurements and facilitate a comparative analysis for different nations.

The WRI report states, "... The increases in concentrations total less than the amount emitted by human activity, so sinks for both CO_2 and CH_4 must have also increased.

The total emission of CO_2 caused by human activities in 1987 was about 8.6 billion metric tons(expressed in terms of total carbon content of the CO_2), but the total in the atmosphere increased by only about 3.7 billion metric tons. Methane emissions in 1987 were about 255 million metric tons but the atmosphere had a net increase of only about 43 million metric tons. (WRI, therefore) ... attributes these atmospheric increases to countries in proportion to the fraction of the total CO_2 and CH_4 emissions that can be assigned to each".

This is tantamount to each country getting an equi-proportionate share in the sinks even if it emits a larger proportion of GHGs. Thus, it is not logical to consider the sources and sinks together. However, for analytical purposes, the above mentioned WRI approach is not modified at present. Further work is intended in the future, challenging the basic WRI approach and presenting an alternative.

Thus only 43 percent of CO_2 and 16.9 percent of CH_4 emitted will be added to the atmosphere for all nations.

<u>IPCC GWP:</u> The IPCC has computed the relative GWP of different GHGs in CO_2 equivalent on the basis of a 100 years time horizon. These estimates, for some of the gases, are presented in Table 1 below.

Table 1. Global warming potential per tonne of gas (in CO_2 equivalent)

	IPCC	WRI
Carbon Dioxide	1	1
Methane	21	70
CFC-11	3500	6400
CFC-12	7300	6400

Deforestation

The extent of deforestation in India has been grossly overstated in the WRI report. Outdated estimates have been relied upon despite the availability of more recent assessments. The WRI has used the National Remote Sensing Agency (NRSA) data published in 1984 for the period 1972-75 and 1980-82. The NRSA estimates suffered from many inadequacies and did not represent the correct forest cover in the country. An assessment made by the Forest Survey of India (FSI) for the period 1981-83 showed wide divergence from the NRSA estimates.

The Ministry of Environment and Forests had recently directed the two national agencies to reconcile their figures (referred to as the reconciled 1987 figure). The FSI made a second assessment for the period 1985-87 (referred to as the 1989 figure). The new (1989) assessment, shown in Table 2 gives a forest cover of 64.01 million hectares compared to the earlier reconciled figure of 64.20 million hectares approximately. Thus, during the last 4 years the annual rate of forest loss works out to only 47,500 hectares.

Table 2: Deforestation in India

Sl. No.	Category	1987 Assessment (Sq. Km)	1989 Assessment (Sq. Km)	Change in Area (Sq. Km)
1.	Dense forest (crown density 40% and over)	3,61,412	3,78,470	(+) 17058
2.	Open forest (crown density 10% to less than 40%)	2,76,583	2,57,409	(-) 19174
3.	Mangrove forest	4,046	4,255	(+) 209
		6,42,041	6,40,134	(-) 1907

Source: [1]

The 1987 and 1989 assessments may not be comparable owing to:

(i) difference in scale that is, 1:1 million in 1987 and 1:250,000 in 1989

(ii) spatial resolutions-79 m using Multi Spectral Scanner in 1987 and 30m using Thematic Mapper (TM) in 1989.

In this regard, The State of Forest Report 1989, (FSI) mentioned, "... However, the intensive ground truth verification made by FSI has resulted in sorting out the real differences from those which are on account of technical reasons, to a substantial degree".

Thus, in our analysis we take the figure of 47,500 hectares as the average annual deforestation over the period 1981-83 and 1985-87.

Based on the ground inventories FSI has calculated the average growing stock of Indian forests to be 65 cubic meters

per hectare[1]. The weight to volume ratio of wood is taken as 750 kilograms per cubic meter, air dry and with 10% moisture content. On this basis the growing stock of wood works out to be 48750 kilograms or 48.75 tonnes per hectare. The carbon content of wood is taken to be 45 percent. Table 3 shows the calculations by TERI using these estimates and WRI's published figures for India assessing CO_2 from deforestation.

Table 3: Carbon dioxide emissions from deforestation in India

		TERI	WRI
1.	Area deforested (000 hectares)	47.5	1,500
2.	Growing Stock per hectares (tonnes/ hectare)	48.75	209*
3.	Wood burnt due to deforestation (000 tonnes)	2316	313300*
4.	Carbon released from deforestation (with 45 percent carbon in wood) (000 tonnes of carbon)	1042	141,000
5.	Additions to atmospheric CO_2 (43 percent of release) (000 tonnes of carbon)	448	61,000

* Calculated.

It is important to note that in making the above calculations TERI has assumed that the entire wood from deforested areas is burnt. In reality, a large proportion of the wood is used for various industrial purposes such as for manufacturing of furniture and railway sleepers, erection of

buildings and other civil work, etc. rather than as fuelwood. However, no data is available in this respect and we have preferred, therefore, to use the higher assumption of all timber from deforestation being burned.

Secondly, a perusal of Table 2 shows that the area under dense forests has registered an increase of 4.7 percent, whereas most of the deforestation has taken place in open forest areas which showed a decline of 6.9 percent. This implies that more carbon has been fixed through increased forest activity than released by deforestation. However, given the paucity of data no accurate quantification is possible, and we have, therefore, excluded the increase in this afforestation from our computations.

Lastly, the amount of afforestation resulting from roadside plantation of trees & shrubs is also not included owing to lack of information.

The above three factors clearly indicate that the level of deforestation considered by TERI & the associated CO_2 emissions are essentially an overestimation of the actual level. Yet, nevertheless TERI's estimates, backed by reliable data, are far lower than those of WRI.

Methane from wet rice cultivation

Lately, several attempts have been made in India to measure the methane flux from paddy fields by the National Physical Laboratory [3,4,5]. On the basis of one such set of measurements, made for estimating the total emissions from

paddy fields in the Indian sub-continent, Dr A.P. Mitra, Director General, Council for Scientific and Industrial Research, India, concluded that the contribution from rice fields in India is in the range of 3-9 Tg of methane per annum.

There are a number of factors like the temperature of the soil, pH value of the soil and the use of fertilizers, which determine the methane emissions from inundated rice fields. However, even at the upper limit of the above mentioned range viz. 9 Tg per annum methane emissions from rice cultivation in India would amount to only half the WRI estimate of 18 Tg. Therefore, the WRI numbers are certainly overestimated in this respect also.

Methane from livestock

Methane emissions from the stomachs of ruminants are directly related to its body weight, level of nourishment, type of diet, particularly, the cellulose forage content and the population of methane producing bacteria.

The National Dairy Research Institute, Indian Council of Agricultural Research, measured methane production to be in the range of 12-20 litres per day for sheep and goats, and 70-85 litres per day for cattle and buffaloes.[6]

Multiplication of these emission factors by the most recent livestock population number [7] gives nearly 5790 thousand tonnes of methane from livestock in India. WRI has overestimated this figure by 73 per cent at 10,000 thousand tonnes.

Table 4 : Methane emissions from ruminants

Type of animal (1)	Methane emission per capita litres/day (2)•	Methane emission per capita kg/annum (3)	Population (millions) (4)••	Total animal CH_4 emissions (000 tonnes) (3)x(4)
Bovine	70	18.3*	192.45	3530
Buffaloes	85	22.3*	69.78	1554
Sheeps	16	4.2*	48.76	204
Goats	16	4.2*	95.25	399
Pigs	-	1.0**	10.07	10
Camels	-	58.0**	1.08	63
Horses and ponies	-	18.0**	0.90	16
Donkeys and mules	-	10.0**	1.16	12
Total				5788

Source : * Calculated using a density of 0.718 kg/m³ for methane [8]
** [9]
• [6]
•• [7]

Conclusions

On the basis of the above computations, it can be concluded that the estimates made by WRI for India are inaccurate, particularly for carbon dioxide from deforestation and methane emissions from rice cultivation and the stomachs of ruminants.

The total global warming potential of different gases (in carbon dioxide equivalent terms) has been recalculated by using the IPCC numbers for all the countries. Table 4 below shows the revised rankings and percentage contributions to the greenhouse gas build-up for the first 15 nations

juxtaposed with WRI's erroneous rankings published in their 1990-91 Report.

Table 5: Greenhouse ranking for the top 15 contributors

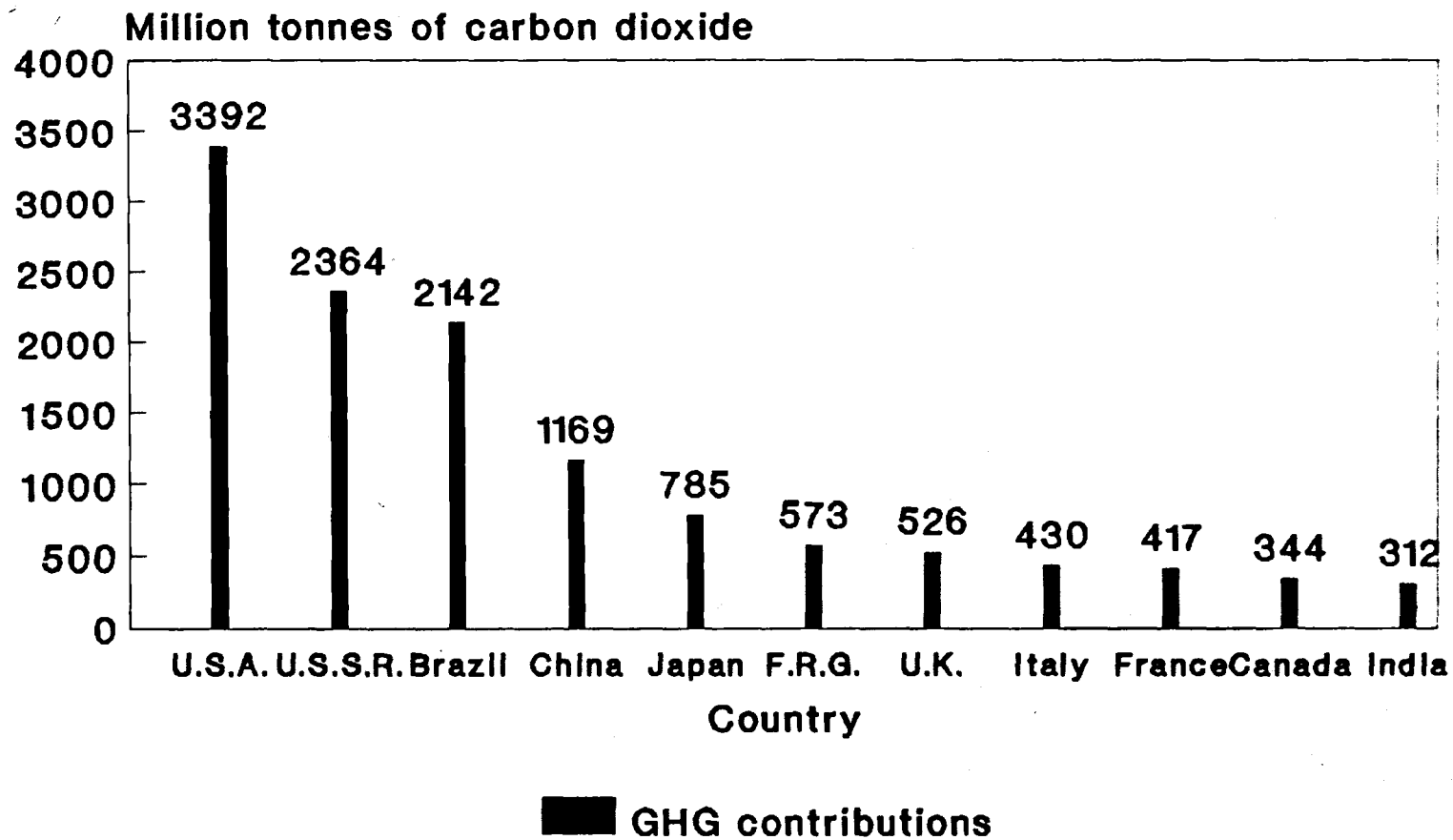
Country	TERI		WRI	
	Greenhouse Index Rank	Percentage Contribution	Greenhouse Index Rank	Percentage Contribution
USA	1	17.5	1	17.6
USSR	2	12.2	2	12.0
Brazil	3	11.0	3	10.5
China	4	6.0	4	6.6
Japan	5	4.0	6	3.9
German Federal Rep.	6	3.0	7	2.8
United Kingdom	7	2.7	8	2.7
Indonesia	8	3.4	9	2.4
Italy	9	2.2	11	2.1
France	10	2.2	10	2.1
Canada	11	1.8	12	2.0
India	12	1.6	5	3.9
Poland	13	1.4	15	1.3
Myanmar	14	1.3	14	1.3
Spain	15	1.3	16	1.2

The above analysis shows that India, placed fifth by the WRI study, now ranks twelfth. This revised ranking follows the WRI's basic approach to which many may find fault since it ignores the concept of equity issues. But this issue will be addressed in a later study to be released by TERI.

According to TERI's estimates, India's share in global warming declines from 3.9 percent to 1.6 percent using WRI's methodology, but using more reliable and unbiased data for India.

The WRI estimates for other developing countries like Brazil and China may also be inaccurate and it is likely that

Net atmospheric increase in greenhouse gases (carbon dioxide equivalent)



Using IPCC GWP numbers & an integration time of 100 years

their shares and rankings may be very different as compared to those shown by the erroneous WRI study. In fact, Jose Goldemberg, currently Minister for Science & Technology in Brazil, and also a member of the WRI Board went public in July 1990 by publishing a letter in the New York Times which challenged WRI data for deforestation in respect of Brazil.

References

1. Government of India, "The State of Forest Report 1989", Forest Survey of India, Ministry of Environment and Forests, New Delhi.
2. "World Resources 1990-91", World Resources Institute, 1990, Oxford.
3. Parashar, D.C., J. Rai, V. Raman, A.K. Saha, D.T. Khathing and V.R. Rao, "Efflux of Some Atmospheric Gases in Slash and Burn Agriculture", Science & Culture, 54, 23-24 (1988).
4. Saha, A.K., J. Rai, V. Raman, R.C. Sharma, D.C. Parashar, S.P. Sen and B. Sarkar, "Methane Emission from Inundated Fields in a Monsoon Region", Radio & Space Physics, 18, Oct. & Dec. 1989, 215-17.
5. Parashar, D.C., J. Rai, Prabhat K. Gupta, R.C. Sharma, N. Singh and B.M. Reddy, "Diurnal Variation and Soil Dependence of Methane Efflux from Rice Paddy Fields in India", presented in the International conference "Chapman Conference", March 1990, U.S.A.
6. Personal communications with Animal Nutrition Division, National Dairy Research Institute, Indian Council of Agricultural Research, Karnal, India.
7. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, Agricultural Statistics at a Glance, 1988, pp97.

8. Handbook of Physics and Chemistry, 64th Edition, CRC Press.

9. Crutzen P. et.al 1979, Biomass Burning as a Source of Atmospheric Gases CO, H_2, N_2O, NO, CH_3Cl and COS, Nature 282.