REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE VI)

TATA ENERGY RESEARCH INSTITUTE
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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

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Impacts of climate change on Indian forests

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Introduction

Out of a total geographical area of 328.726 million ha, forest ecosystems in India occupy over 66.8 million ha constituting nearly 20.3% of the total land area of the country (Table 1), forestry being a major land use next to agriculture. Nearly 41.4% (136.177 million ha) of the total geographical area is under agriculture (probably the highest in the world) and over 101.8 million ha (31.0%) is under other land uses. No returns exist for 7.3% (23.877 million ha) of the total land area of the country.

While the land use statistics (Table 1) place the area under forests at 66.858 million ha, the area officially recorded as Forest, with or without tree cover, by the State Forest Departments is of the order of 75.18 million ha or 22.8% of the total geographical area (1,2). Furthermore, the reconciled estimates of actual forest cover arrived at by the National Remote Sensing Agency (NRSA) and the Forest Survey of India (FSI) was only 64.2041 million ha (1987 assessment based on imagery of 1981-83) and 64.0134 million ha (1989 assessment based on 1985-87 imagery). This works out, respectively, to 19.52% (1987 assessment) and 19.47% (1989 assessment) of the total geographical area of the country (1, 2). There has thus been a reduction of 0.19 million ha (0.29%) of forest cover over a four year period (1981-83 to 1985-87); the annual rate of loss being 47,500 ha. The actual forest cover is 85.4% and 85.1% of the officially recorded forest area (75.18 million ha) according to 1987 and 1989 estimates respectively.

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Resource base

Floral regions

The forest flora of most parts of the Indian subcontinent is now fairly well known (4) though there are certain regions, e.g., the richer areas in the Northeast, which are rather imperfectly explored. The flora of India varies considerably in different parts of the country both in specific identity and in the number of species. Some species occur throughout the country whilst others are restricted to very small areas.

Comparative studies of the recorded floras of the various parts of the country have led to the recognition of a number of floral regions each with characteristic features. These regions are: (i) Western Himalayan, (ii) Eastern Himalayan, (iii) Indus Plain, (iv) Gangetic Plain, divisible into dry humid and tidal areas, (v) Central India, (vi) West Coast (Malabar), (vii) Deccan Plateau (with Carnatic), (viii) Northeast India, and (ix) Andaman and Nicobar Islands. The Western Himalayan flora differs from the Eastern Himalayan in the greater representation of conifers. While the European element is conspicuous in the former, the Malayan, Chinese and Burmese are prominent in the latter. The Indus plain flora has received important North African components. If the floras of the nine regions mentioned above are compared with those of adjacent countries, affinities are brought out suggesting the probable origin of the differences. It is evident that there is no 'Indian flora' as a separate entity, but the vegetation of the country is compounded of several elements which are present in very different proportions in different areas. These elements are, in order of dominance for the country as a whole: (i) Malayan, (ii) European and Mediterranean, (iii) Indo-African, (iv) Tibetan and Siberian, practically confined to the Himalayas, and (v) Chinese and Japanese, mainly in the Eastern Himalayas. All the regions have the majority of their species in common but also an appreciable number that are peculiar to them, or are common with only some of the other regions (5).

India has a high degree of endemism in its flora second only to Australia (6). It has been computed that at least 47% of the species of dicotyledons in the country are endemic, the largest proportion occurring

in the Himalayan region which has been isolated by glaciation and orogenesis. The Himalayan forests are also the largest reservoirs of biodiversity, genetic variability and gene pools.

Land Use		Area (Million ha)	% of the total reporting area	% of the total geographical area
1.	Forests	66.858	21.9	20.3
2.	Area not available for cultivation			
(a)	Area under non-agricultural uses	20.809	6.8	6.3
(b)	Barren and unculturable land	20.391	6.6	6.2
3.	Other uncultivated land (excluding fallow)			
(a)	Permanent pastures and other grazing land	11.848	3.9	3.6
(b)	Land under miscellaneous tree crops and groves not included in net area sown	3.535	1.2	1.1
(c)	Culturable wastelands	15.626	5.1	4.8
4.	Fallow lands			
(a)	Fallow other than current fallow	11.134	3.7	3.4
(b)	Current fallow	18.471	6.1	5.6
5.	Agriculture (Net area sown)	136.177	44.7	41.4
6.	Total reporting area	304.849	100.0	
7.	Area for which no returns exist	23.877		7.3
8.	Total geographical area	328.726		100.0

Note: Area officially recorded as Forest (with or without tree cover), by the Forest Departments, is 75.18 million ha (22.8% of the total geographical area) (1,-2).

Source: (3).

Forest types

The extensive dispersion of forest over the Indian subcontinent is accompanied by considerable diversity in their specific composition. Accordingly, the forests of the country have been divided into 16 Type--Groups (4) ranging from Tropical Wet Evergreen forests to Alpine types; the Tropical Deciduous types (both moist and dry) constituting the bulk (65.48%) of our forests. Nearly 8% of the actual forest cover consists of Tropical Wet evergreens, just about 9% of montane Subtropical forests including Subtropical pine (Pinus roxburghii - over 6%) and over 10% of montane Temperate and Alpine forests (1).

Altitudinal distribution

The altitudinal distribution of the actual forest cover for the country is shown in Table 2. Over two-thirds of the actual forest cover in the country is located at elevation less than 600 m and the occurrence of forests is negligible over 4,000 m.

Table 2: Altitudinal Distribution of Actual Forest Cover (1987 Assessment)

Altitude (m)	Geographical area (Million ha)	Actual forest cover	Actual forest cover as % of geographical area	Actual forest cover as % of total
Upto 600	255.3	42.6276	16.7	66.4
600-1,800	43.4	16.5057	38.0	25.7
1,800-4,000	30.0	5.0708	16.9	7.9
Total	328.7	64.2041	19.52	100.0

Source: (1).

Species composition

Of the total recorded forest area of 75.18 million ha, coniferous forests constitute 4.1 million ha (5.5%), the balance of 94.5% (71.1 million ha) consisting of non-coniferous species. While relatively pure coniferous forests are situated in the high mountain areas of Northern and North-eastern regions and there are also extensive gregarious forest of sal (16%) and teak (13%), perhaps both as a result of human interference, and a few other species of local occurrence, the moister semi-evergreen and evergreen forests are composed of a large number of species. Bamboos (including plantations) occur in nearly 9% of the recorded forest area (7). Consequently, the utility of different species and their values in the context of present uses and future utilisation, varies from region to region.

Forest cover density

Whereas the outer Himalayan forests and evergreen forests of the West Coast and Northeast are fairly well stocked, large areas in Central India region, Indo-Gangetic plain and in the coastal strips and in other fertile valley systems are either partially stocked or entirely devoid of forests. Of the actual forest cover of over 64.01 million ha (Table 3) only 37.8470 million ha are of adequate density (crown density 40% or more), while little over 25.74 million ha are open forest with crown density varying from 10 to 40%. Over 0.42 million ha constitute the mangroves. Thus, the effective forest cover (37.8470 million ha- 1989 assessment) is limited to 11.51% of the geographical area of the country.

Table 3: Actual Forest Cover by Density Classes

Density class	1987 Assessment (1981-83 Imagery) (Million ha)	1989 Assessment (1985-87 Imagery)
1.Dense Forest (Crown density above 40%)	36.1412 (10.99)	37.8470 (11.51)
2.Open Forest (Crown density 10 to 40%)	27.6583 (8.41)	25.7409 (7.83)
3.Mangroves	0.4046 (0.12)	0.4255 (0.13)
Total	64.2041 (19.52)	64.0134 (19.47)
4. Scrub Area (Tree lands with less than 10% crown density)	7.6796 (2.34)	6.6121 (2.01)

Note: Figures in brackets indicate percentage of the total geographical area.

Source: (2)

Growth and yield

The growing stock of the actual forest cover (64.2041 million ha) in Indian forests ranges from as low as 10 m^3 per ha in Rajasthan to as high as 277 m^3 per ha in the coniferous forests of Kulu valley, the average growing stock being 65 m^3 per ha (1,2). The total estimated growing stock, of wood, in the country is placed at 4,196 million m^3 while the recorded production of wood (timber and fuelwood) during the last 10 years has varied from 26 million m^3 to 32 million m^3; average annual production being of the order of 30 million m^3. Unrecorded

production in the form of dead/dying and annually fallen wood which is removed as head-loads for domestic energy is estimated at 22 million m^3. Thus, the average annual production, within silviculturally permissible limits, is 52 million m^3 which may reasonably be assumed to be the net annual increment amounting to 1.24% of the total growing stock. Considering the recorded forest area of the country (75.18 million ha), the average annual production of 52 million m^3 works out to 0.7 m^3 per ha.

On the basis of field inventories carried out by FSI, it is reported that India's forests are not capable of producing more than 90 million m^3 of wood, annually, because of the existing state of our forests. This figure is about three times greater than the current annual average production of 30 million m^3. In fact, the annual production of wood in any year since the beginning of scientific forest management in India has not exceeded 32 million m^3 (2).

Natural regeneration

Excessive grazing, frequent fires and other biotic factors have affected adversely the natural regeneration of our forests to a considerable extent. Indications are that except in Andaman and Nicobar Islands, natural regeneration is either absent or inadequate in 52.8% of the forest area of the country (1), which is rather alarming.

Man-made forests

While the existing naturally regenerated forests of the country continue to provide wood raw material, natural regeneration systems are not able to adequately cope up with the rising demands of wood because of many limitations including the absence of natural regeneration in a large proportion of our forests. This has led to the adoption of artificial regeneration practices and so far (1988-89) plantations have been raised over an area of over 15.365 million ha (8, 9).

Minor forest products

Reference needs to be made to a host of non-wood forest products (NWFP) like canes, gums, resins, dyes, tannin, lac, fibre, floss, medicinal plants, etc. obtained from forests which sustain a large number of rural cottage and other industries and are also exported.

Native fauna

India is gifted with a very rich and varied fauna due to the diversity in her physical features revealing itself in the corresponding differences in the types of forest and the variety of wildlife, which can live in such physically complex areas. There are about 500 different species of mammals, over 1,200 species of birds, 250 species of snakes, about 30,000 species of insects and many species of fish, reptiles and amphibians besides gorgeous and gigantic oceanic fauna. Some unique species like the gaur - the biggest oxen, the black buck, four-horned antelope, the musk deer and the lion tailed macaque are found no where else in the world.

The existing wildlife in India is an admixture of Indian, Indo-Chinese, Ethiopian and European elements, each predominating in those parts of the country which are most suited to their requirements. The rate of endemism is 62%, 33%, 8% and 4% in amphibians, reptiles, mammals and birds respectively (10).

Grasslands

Grass and grazing constitute the major source of fodder in India. While grasses as fodder are not cultivated on any scale in the country, most of the grass production is obtained from natural grasslands within forest areas and areas outside the forests. The extent of grass producing areas in the country (excluding forest) is estimated to be of the order of nearly 44 million ha or over 13% of the total land area of the country (11).

Most of the grasslands in the country are very poor, degraded and overgrazed and as such their productivity is very low which is estimated

to be, on the average, about 3 and 1.5 tonnes/ha/year from forest and other grass producing areas respectively (12).

Protected areas and nature reserves

Data obtained from landsat imagery of 1985-87 (1989 assessment) put the extent of mangrove cover in India at 425,500 ha. However, according to field surveys the total mangrove area, including the area permanently under water, is reckoned at about 674,000 ha (13). Wetlands which exhibit significant ecological diversity, primarily because of climatic and topographical variability extend over an area of over 4 million ha (14).

There are 73 and 412 (1990) national parks and sanctuaries which constitute over 4 and 17% of the total geographical area and recorded forest area (75.18 million ha) of the country, respectively (15). A network of 188 preservation plots exits throughout the country covering an area of over 8,400 ha both in natural forests and plantations (16). Thirteen sites (3,427,500 ha) have been proposed to be declared as biosphere reserves (17).

India has a coastline of nearly 7,517 km and about 2 to 5 m of land, on an average, is reported to be lost every year due to sea erosion at different places. Apart from other economic activities like fishing, exploitation of petroleum resources, etc., a number of popular beach/sea resorts as centres of recreation have been developed. Large areas in the country are ecologically fragile.

Climatic changes

In a future scenario of doubled Carbon dioxide, the Intergovernmental panel on Climate Change has indicated the following climatic changes for Southeast Asia (18, 19).

- Current best estimates for the year 2020 in Southeast Asia (5 -30 - °N, 70 -102 E) indicate general warming will occur throughout the year by 1 to 2°C. Precipitation will change little in winter but generally increase throughout the region by 5-15% in summer. Summer soil moisture will increase by 5-10%.

- Sea level is expected to rise mainly due to the thermal expansion of the oceans and the melting of some land ice. Sea level will rise by about 20 cm (with a probable range of 10-32 cm) by 2020, and by 2070 it will have risen by about 45 cm (with a range of 33-75 cm).
- With the possible exception of an increase in the number of intense showers, there is no indication yet that weather variability will change in the future.
- There are no indications about the frequency and intensity/shifts of tropical and mid-latitude storms from climatic models.

The above indications are based on simulation results of various climate models and, in general, confidence in these estimates is low especially for changes in precipitation and soil moisture.

From the above, it can be seen that the main impacts of global warming on Asia are expected to be sea level rise and a possible increase in climatic variability. The areas sensitive to sea level rise in Asia are the major deltas, such as the Ganges-Brahmaputra-Meghna delta of Bangladesh and the Mekong delta of Viet Nam, and low-lying islands like the Maldives.

Impacts on forests

In view of the great diversity in its physical features and climate and the extensive dispersion of forests accompanied by considerable variation in their specific composition, the impacts of climate change on forests, in India, are expected to be different in different regions of the country.

Regional rise in temperature could create moisture stress particularly in the drier parts of the country which in turn could cause poor microbial and mycorrhizal activities and increased drought conditions leading to loss of tree vigour and susceptibility to insect and fungal attack. Most of the sal (Shorea robusta) forests in the Shivalik and peninsular India are today experiencing higher rate of mortality primarily due to drought conditions (20,21). The dying process may take as long as 2 to 10 years.

Inadequate soil moisture during drought year seems to be a cause of heavy sal mortality in dry regions as well as along water courses in Bihar (22). Sal trees along water courses develop superficial root systems when the water table is high. During persistent drought conditions these root systems, not used to moisture deficiencies, experience excessive drought and the trees die. On poor or shallow soils of dry regions even the normal soil moisture fluctuations can very soon approach critical levels for survival of sal. On the other hand, in years of scanty rainfall during drought years, surface rooters stand better chance of survival by utilizing the surface moisture available (23). In Uttar Pradesh, investigations of the severest and most widespread drought of 1907-08 in the moist plains sal forests revealed that while in some cases trees died on a large scale, over patches of considerable area, elsewhere, mortality was in small groups (23).

There is increased evidence of lowering of water table in dry deciduous forests of Madhya Pradesh. While in 1951 the average depth of water in South Raipur Forest Division was 7.33 m, it receded to 8.95 m in a span of 15 years (1966), going further down to 11.22 m in 1988 (24). Lowering of water table has been correlated with the mortality of sal (23, 25, 26). Under abnormal rainfall and temperature conditions, the drought period lengthens beyond the normal limit of tolerance leading to mass mortality of sal (27).

Future increases in temperature could considerably increase the rate of sal mortality in India. Other exacting species growing in arid and semi-arid conditions may similarly be affected by the lack of available moisture. However, it is difficult to predict the extent to which moisture stress caused by increased temperature would be offset by increase in levels of precipitation. It is likely that surface rooters may survive the stress conditions during summer drought periods.

Increase in temperature particularly in the high latitude forest may enhance the breeding conditions for insects and pests and extend their ranges. This could endanger pure stands of natural forest as well as monocultural plantations being raised in the country. Most of the

gregarious species in India grow in pure stands and therefore, may be prone to increased insect and pest damages in future.

Fire damage is expected to increase with the susceptibility of forests. Warmer drier sites could have a higher incidence of severe fires, specially where stands are in a state of decline because of climatic change. Occurrence of frequent fires is a major cause of injury to forests in the country. Retrogression caused by forest fires may completely alter the composition of forests by the elimination of fire tender species as seen in the substitution of deciduous forest for moist evergreen forest in many places, and of scrub or bamboo breaks for evergreen hill forest in the higher Himalayas. Tropical wet evergreen forest which is exceptionally sensitive to fire has been eliminated by fire from large tracts in South India in favour of more resistant species of the deciduous forest. The abrupt edge of the evergreen forest often reveals this history. Similar is the driving back of the temperate evergreen forests in favour of grasslands in South India, though lack of frost hardiness in the trees is also believed to play a part.

Even in the case of trees that are fairly fire hardy when above a certain size, fire will effectively prevent all regeneration except for a limited number of specially adapted species. Forests comprising of fire sensitive species as well as those where deliberate burning is practiced would, therefore, be exposed to increased risks of fire damage. Chir pine forests, and tropical dry deciduous forests could be exposed to increased risks of forests fires. The north- eastern region where shifting cultivation is practiced could similarly experience high incidence of forest fires due to increased temperature.

Under the scenario of doubled carbon dioxide, area under subtropical forest is expected to decrease by 22% whereas rain, wet, moist and dry areas of tropical forests are expected to increased by an extent of 28% (28). The area of subtropical forests in India could, therefore, decrease from a current level of 5.77 million ha to 4.50 million ha. The increase in extent of tropical forests could be about 14.56 million ha amounting to an area of 66.56 million ha.

The geological history of the flora of the Jhelum valley in Kashmir reveals existence of rich deposits of fossil impressions in some of the Karewa clays laid down in the Tertiary lake of which a part still exists. Identification of the leaves and other parts of a large number of species has been possible and the evidence has been greatly extended by fossil pollen. The most interesting features are the proof that oaks, now virtually absent from the valley, once predominated, and that other coniferous genera such as Larix were present though no longer found in part of the Western Himalaya now (29). Palynological evidence also suggests that the subtropical and montane temperate flora extended more widely in protohistorical times than at present. Pollen grains recovered from Maski (Andhra Pradesh) in lime deposits dating to second century B.C. have been identified as resembling those of pine, Brassica, Campanula, Stellaria, etc. Some pine tracheids have also been identified (30). The present vegetation of this site in gneissic country in Andhra Pradesh is predominantly dry deciduous scrub.

The above, however, could be an exception as available evidence indicates that the climate and vegetation of India have been essentially stable during the last five millennia, except for changes brought about by biotic factors attendant upon settling of virgin land and possible slight shifts in monsoon regime and drainage pattern which have probably accentuated retrogression (31).

Knowledge of the Harappan Period (3000-1500 B.C.) tends to establish that the then climate, although not arid, was certainly dry. Forests and marshlands must have existed, but the forest need not have been very moist (32).

At the time of Alexander's invasion and retreat, Sind was perhaps still a fertile track although by AD 712 Southern Baluchistan had certainly reached its present aridity. The Indus basin might have, however, retained a somewhat moister climate till later times. Dense forests grew near Ohind, sufficient to enable Alexander to construct the first Indus flotilla. Hiuen-Tsang in his record of the climate and vegetation of India informs that in general the plains below the western mountains were dry and saline although there were dense and shady

forests near Jallandhar, now a typical dry tract; there were good forests and rivers near Ahichhatra (near Barielly) and Malwa was well forested. This indicates that while desert conditions had settled in the lower Indus valley, the south-western part of Rajasthan and the Punjab plains from Multan to Jallandhar had not been desiccated to anything like their present condition.

It may be concluded that while a certain degree of desiccation has certainly taken place, the vegetation and climate in northern India were not much different 2000 years ago from what they are now (32). Deforestation has proceeded apace and the local climate rather than natural climate has changed and has caused a profound change in the vegetation.

In view of the scant information available for vegetational shifts in India, no conclusions can be placed on record regarding future zonal shifts of vegetation. Marginal forest areas, on the higher extremes of temperature ranges, like the tropical thorn forests may suffer an extinction of species. Desertification process in the Kutch region could be catalyzed increasing the extent of desert thorn forests in states of Rajasthan, Gujarat, etc. Warming may also tend to raise the timber line in the Himalaya. The high level Himalayan species like birch, junipers, etc., of the Western Himalaya and Rhododendrons of the Eastern Himalaya could encroach into erstwhile subalpine and alpine regions, the latter, in their turn, having moved higher up in the Himalaya.

While in some areas, forests may expand because of warming, in some others there may be increased productivity of forests due to CO_2 fertilisation effects (increased photosynthesis). This is, however, open to question because it is not certain that increasing CO_2 concentrations would increase the efficiency of use of growth limiting inputs like water, N, P etc., in the context of changed climatic conditions.

It has been stated that regeneration would be enhanced for species with seed and vegetative reproduction. However, success rate of plantation establishment could be reduced. This would mean that those species which are being regenerated primarily through plantation programmes like e.g. Teak, Eucalyptus could suffer from regeneration

problems because of increased harshness of site conditions and increased competition from other vegetation.

Sea level is expected to rise mainly due to thermal expansion of the oceans and melting of some land ice by about 20 cm by 2020 and by 2070 it would have risen by about 45 cm. Submergence of coastal regions in the country could lead to a loss of existing coastal and estuarine ecosystems and creation of new ones. The Sunderbans of West Bengal and Casuarina plantations raised along the Indian coast could suffer inundation and consequent loss of valuable ecosystems.

Changes in the habitat and availability of food and water may increase pressures on wildlife thus affecting their very existence. In case of endangered species, such changes could be disastrous. Since most natural ecosystems, particularly forest could experience increased mortality and associated short or long term losses in productivity, wildlife could be significantly disrupted. Vegetational changes in the past have had adverse impact on the country's wildlife. The swamp deer is known to have crowded the reed beds of the Indus. Tens of thousands of black buck were estimated to inhabit the Punjab region. The rhino and the wild buffalo, favouring moist conditions, inhabited many terrains of Western India which are deserts or semi-deserts today. The tiger population had reduced from 40,000 at the turn of the century to only 1,827 in 1972. Although indiscriminate game hunting and poaching is one of the reasons for this unfortunate trend, it is also certain that vegetational and consequent climatic changes have significantly altered the number and distribution of wildlife in India. Logical extrapolation of the trend would mean that future climatic and vegetational changes might similarly affect wildlife by causing changes in natural habitat conditions.

As climatic changes are expected to affect the extent and nature of forest ecosystems, they would consequently result in loss of biodiversity in general and the survival of vulnerable/endangered species in particular through changes in population size and distribution. The reasons for this would be changes in pattern of precipitation, evaporation, wind, frequency of storms, fire, sea level rise, and loss of coastal

wetlands and coral sites. The present human land use practices would be impediments to shifting of their ranges. Besides, spread of forest tree species and corals may not keep pace with the climatic changes (10). The effect would probably be more pronounced in the Himalayan region which has high biodiversity, genetic variability and gene pools.

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Potential of solar thermal applications for industrial process heat

Chandra Shekhar Sinha

Background

The likely future GHG (greenhouse gases) emissions from developing countries are of special concern, particularly by the developed countries, as the demand for energy services is likely to rise rapidly in the coming years. The current and future CO_2 emissions[1] from India (and China), is being viewed with growing concern in the context of climate change. As a strategy towards reducing CO_2, renewable energy sources are likely to receive increased attention.[2] Different technologies based on renewable sources of energy have been developed and/or deployed[3] in attempting to build sustainable energy systems which also reduce environmental concerns such as that of climate change. Financial commitment poses, perhaps, the most serious hurdle in the context of developing countries opting for technologies relying on renewable forms of energy. While this may no longer be the primary issue in the context of developed countries with environmental concerns and long term sustainability becoming paramount, investment requirements cannot be ignored in the context of more immediate concerns (such as safe drinking water, creating employment opportunities, adequate health care and education facilities, and so

1. In 1989, the estimated CO_2 from industrial source (including power sector) in India was about 652 million tonnes. Land use shifts is believed to have contributed an additional 120 million tonne that year (WRI 1992).

2. See Grubb (1990) for the possible role and the relevance of renewables in the coming years. This issue has also been the focus of the renewables series of *Energy Policy* from January, 1991 to September, 1992. Of particular relevance in the current context are the Jackson (1991, 1992), Foley (1992), Sorensen (1991), Hall, Rosillo-Calle, and de Groot (1992).

3. For a review of the renewable energy programme in India see Sinha (1992).

on) of developing countries. Opportunity costs of higher investments for a sustainable energy system are likely to be much higher, both qualitatively and in terms of quantity.

Potential and cost of GHG mitigation measures

Cost of measures for reducing GHGs emissions have received some attention in the context of climate change induced by increased GHG emissions. The Climate Change Convention requires the developed countries to bear the agreed full incremental costs for mitigation for GHGs. For the purpose of global negotiations and possible financial transfers supply curves for mitigation measures would be required. Substantial effort have been made to estimate the potential for reducing the emissions of GHGs and their costs in the context of climate change. Manne and Richels (1990) have estimated the likely range of cost to the United States of CO_2 emission limits. Williams (1990) examined the assumptions regarding the technologies in the Manne and Richels paper concluding that the range of costs were likely to be lower than estimated by Manne and Richels. Hall *et al.* (1990) have examined the techno-economics of biomass based energy systems in the context of CO_2 sequestering. Nordhaus (1991) has reviewed the methods and the estimates of diverse studies, has discussed conceptual issues relating to the GHG cost reduction curves and 'crudely' estimated the cost reduction curve. Mills *et al.* (1991) examined a variety of existing and emerging supply and end-use technologies, their costs and emission savings in the context of diverse case studies (of USA, Sweden and the state of Karnataka, India) and concluded that implementing many of the measures would result in net benefits to the society and that 'wait-and-see' stance is not economically justifiable. Jackson (1991) proposes a methodology closely resembling the least cost integrated planning approach and examines seventeen different technologies within this framework in the context of Britain. Earlier, Donaldson and Betteridge (1990) had examined supply options for Britain in the context of climate change.

Some estimates of the costs of reducing CO_2 emissions have been made in the past for India.[4] In the studies for India the major drawback has been the use average cost figures for the different options and technologies with the implicit assumption of the performance of the technology in computing the cost of offset CO_2 emission. More realistic estimates require the consideration of the site specific nature of both, the costs and the likely performance of the renewable energy technologies. Earlier, based on the level of development of different renewable energy technologies in the Indian context, the exercise of constructing supply cost curves of CO_2 reduction focuses on windfarm power generation and small hydro on existing irrigation dams and canal drops in India had been made by Hossain and Sinha (1992). Both, the absolute and the incremental supply cost curves for CO_2 offset through the use of these technologies were constructed by Hossain and Sinha (1992). Of the two options, the use of wind electric generators in windfarms was found to offer much higher potential for energy paths to lower CO_2 emissions but the estimated costs are substantially higher than the costs of small hydel.

In this paper, we attempt to quantify the potential of low temperature solar thermal applications for industrial process heat and to identify the industrial sectors where solar hot water systems for industrial process heat have high potential. The reason for focusing on this particular application is the recent estimate of the economics of solar hot water systems by Kishore (1992). According to the cost and benefit estimates, Kishore (1992) indicates that, at the present costs of solar flat plate collectors, only applications with round the year requirement for thermal energy is cost effective. For this reason we concentrate on the industrial process heat applications of the solar hot water technology in India.

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4. TERI (1990) has estimated average cost of mitigation/ reduction measures for India. No attempt had been made in that study to compute the incremental costs. See Mongia *et al.* (1991) in which a multi-sector linear programming model with the objective of minimizing the economic cost for the exogenously determined energy services has been used.

The solar energy source

The primary source of heat and light on earth is the sun. At the outer atmosphere the solar energy constant is 1373 W/m^2. This energy is in the form of radiation and spans a range of wavelength with the visible rays accounting for about 46% of the sun's radiation while 49% is in the infrared region.

The atmosphere affects the quantity and the type of radiation reaching the surface of the earth. Dust and clouds may scatter the radiation (such radiation is referred to as *diffuse* radiation) or but a part may remain un-scattered (called *direct* or *beam* radiation). On the surface of the earth, the total (often referred to as the *global*) radiation is the sum of the diffuse and the beam component and is called *insolation*. The maximum insolation available on a clear day is normally 1000 W/m^2.

The useful thermal energy generated from a solar collector would depend on the

1. collector parameters (nature of absorber, heat losses, etc.),
2. utilisation temperature, and
3. solar radiation characteristics.

Solar flat plate collector water heating systems

In the early stages of the programme (mid seventies), the absorber consisted of aluminum roll bonded panels with a suitable passage between the bonded sheets for the passage for flow of the fluid to be heated. In the course of operation of these systems it was found that for open loop applications the impurities in water let to corrosion of the aluminum sheets leading to leakages. To counter some designs of collectors using mild steel were developed but the major constraints with such systems were the high weight and thermal inertia of the collector. Spot welding of two sheets of mild steel were also tried but found unsuitable due to corrosion problems. Subsequent developments have resulted in flat plate collectors which use copper tubes as flow passages with aluminum or copper sheets as the absorbing surfaces. Collectors with copper tube and copper sheets (referred to as the copper-copper collectors) have been found to have better performance though their costs are substan-

tially higher than the copper tube, aluminum sheet (copper-aluminum) absorbers.

The system design in india is broadly classified on the basis of the type of flow of the heated water. *Thermosyphon systems* often have a 2 m^2 flat plate collector and a 100 litre storage, often of stainless steel. A number of flat plate collectors can also be connected together with a single, larger capacity storage. Systems up to a capacity of 3000 litres (using up to 30 collectors of 2 m^2) have also been installed. As the name indicates, no forced circulation of water (by the use of a pump) is necessary: the flow is due to the density gradient created by the heating of water. Most commonly used for domestic hot water systems, a copper-copper collector is often used. The technology is believed to be well developed except for extremely cold conditions as in the states of Jammu and Kashmir, Himachal Pradesh, the North Eastern States and hill districts of Uttar Pradesh.

The second broad design are the *forced flow hot water systems*. The forced flow systems may also have a heat exchanger. The heat exchanger is particularly desirable when the water is unsuitable (due to dissolved solids) for heating due to corrosion problems in the tube of the collector. Demineralised water is normally used in the primary loop and the raw water is heated while it circulates in the secondary loop. Separate pumps are used for the forcing flows in the two loops. As is obvious, the design requirements in such collectors is more stringent and care is required to ensure optimized the heat transfers between the two loops.

Industrial hot water requirement

Solar heated water from flat plate collectors can be used directly in the industrial process or can be used to pre-heat water in cases where the water (or steam) is required at temperatures higher than 85°C. The major constraint for solar hot water applications in industry may be the space constraints. Solar radiation is a dilute form of energy with the radiation intensity being lower than 1 kWh/m^2 while the energy demand intensity in industries may be very high.

The breakdown of the process heat energy requirements according to the temperatures at which the heat is required is vital for an assessment of the potential for solar energy applications.

Kreider and Kreith (1991) report that about 7.5% of the thermal energy requirements in the United States were for applications below 100°C and that about 26% were for below 200°C applications. It must be recognised that there is no single value for the process energy (or, in general, energy) requirement per unit output for any process. Energy efficiencies vary form plant to plant because of age, state of repair of equipments, or minor variations in procedure.

The *Energy Research and Development Administration (ERDA)*/ Battelle survey in the United States was performed from the point of view of process requirements rather than on the current methods of using heat. Thus, the temperature of major interest for a particular application was the required temperature of the process material rather than the temperature at which the heat is currently provided. Much of the heat of high thermodynamic availability is wasted because it is used for low temperature applications. A solar process heat system should be designed to satisfy the needs of the process and not merely to substitute for the current method of providing heat. Steam is a convenient medium of transporting energy within a particular plant. Often, steam is generated at the highest temperature required in the plant and used for lower temperatures as well.

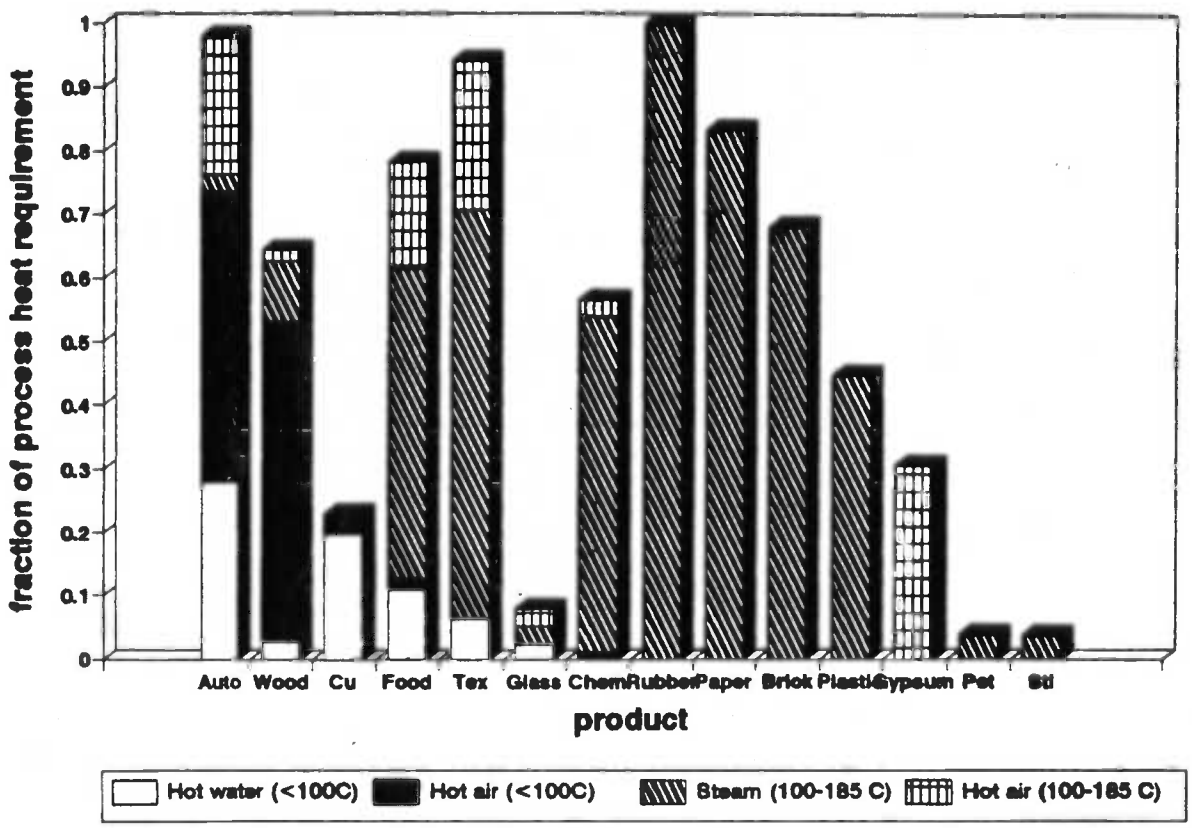
A break-up of the process heat requirement by temperature is provided in Table 1. The energy carriers are hot water, steam and hot air (both at different temperatures) or direct heat. For selected industries important in the Indian context, the process heat requirement is depicted in Figure 1. A note of caution on the low temperature requirement for automobile industry is required. The ERDA/Battelle survey defined this as the assembly plant where the process of painting was found to be a major thermal process energy consuming activity. The energy indicated. in the table excluded the energy used for space heating, process cooling, shaft power or other forms of mechanical energy used in a particularly industry.

Table 1: Estimates of industrial process energy requirements by temperature

Sector	Hot water	Steam		Direct heat/ hot air			Total Energy		
	100°C	100--185°C	>185°C	100°C	100--185°C	>185°C	<100°C	100--185°C	<185°C
Automobile and trucks	28%	3%		46%	21%	2%	74%	24%	98%
Copper	20%			3%		77%	23%	0%	23%
Food processing	11%	49%	18%	2%	17%	3%	13%	66%	79%
Textiles	6%	65%	1%		23%	4%	6%	88%	94%
Lumber	3%	10%	2%	50%	2%	33%	53%	12%	65%
Glass	2%	3%			3%	92%	2%	6%	8%
Chemicals (inorganic)		53%		1%	3%	43%	1%	56%	57%
Plastics		45%	55%				0%	45%	45%
Petroleum refining		4%	12%			84%	0%	4%	4%
Paper and pulp		83%				17%	0%	83%	83%
Ceramics						100%	0%	0%	0%
Steel and iron		4%				96%	0%	4%	4%
Rubber manufacture		100%					0%	100%	100%
Aluminum			38%			62%	0%	0%	0%
Cement						100%	0%	0%	0%
Coal mining and cleaning						100%	0%	0%	0%
Mining (Frasch sulphur)		100%					0%	100%	100%
Concrete blocks and bricks		68%	32%				0%	68%	68%
Gypsum			69%		31%		0%	31%	31%

source: computed from Battelle, 1977. Volume 2, page 6

Figure 1. **Process energy requirements below 185 C**



From the table and Figure 1, the major industries with potential for the use of solar collectors (for low temperature applications) are for textile, wood seasoning, automobile assembly, copper making, food processing. For some other manufacturing processes, solar thermal technologies exist (see Table 2) but the existing costs are high and experience in India is limited and therefore the potential is restricted.

Table 2: Industrial process heat and solar thermal application possibilities

Potential applications for solar thermal energy systems for industrial process heat							
Industry/process	Energy form (*)	Temperature (°C)		Solar Technology (@)			
		from	to	1	2	3	4
Aluminum							
Bayer process digestion	s		216				X
Automobile and truck manufacture							
Heating solutions	s, w	49	82	X	X		
Heating makeup air in paint booth	a	21	29	X			
Drying and baking	a	163	218			X	X
Concrete block and brick							
Curing product	s	74	177			X	X
Textiles							

Washing	w	71	82	X	X		
Preparation	s	49	113	X	X	X	
Mercerizing	s	21	99	X	X	X	
Drying	s	60	135	X	X	X	
Finishing	s	60	149		X	X	X
Paper and pulp							
Pulping (kraft)	s	182	188				X
Liquor evaporation (kraft)	s	138	143			X	X
Bleaching (kraft)	s	138	143			X	X
Drying (paper making)	s		177				X
Food processing							
Washing	w	49	71	X	X		
Concentration	s, w	38	93	X	X	X	
Cooking	s	121	188			X	X
Drying	s, a	121	232			X	X
Synthetic rubber							
Initiation	s, w		121				X
Monomer recovery	s		121				X
Drying	s, a		121				X
Plastics							

Initiation	s	121	146			X	X
Steam distillation	s		146			X	X
Flash separation	s		216				X
Extrusion	s		146			X	X
Drying	s		188				X
Blending	s		121			X	X
Glass							
Washing and rinsing	w	71	93	X	X		
Laminating	a	100	177			X	X
Drying glass fibre	a	135	141			X	X
Decorating	a	21	93	X	X	X	

(*) a: air; s: steam; w: water

(@) 1. Shallow ponds or simple air heaters
2. Flat plate collectors
3. Fixed compound surfaces
4. Single axis tracking troughs adapted from: Solar Energy Handbook

For India, estimates for similar temperature classification for different processes are difficult to find. Based on a diverse set of sources such as the National Productivity Council, Chaturvedi and Kumar 1990 (Table 3), Industrial Energy Group, TERI (Table 4) has been compiled to be indicative of the process heat requirement for some manufactured products in India. A note of caution is also required here. The diverse source of data along with lack of information as to how these were obtained makes the information provided in this table prone to inaccuracies of a level higher than those of the ERDA/Battelle estimates. These numbers are therefore, at best, indicative and should be treated as such.

Table 3: Estimates of process heat energy requirement in India

	up to 60°C	up to 80°C	Steam (140°C)
Milk	0.2 l/l		0.15 kgm Total of 100 kcal/kg
Hotel			
summer	400 lpd/room		
winter	800 lpd/room		
Textiles			
Finishing			3 kg/m
dyeing (power loom)		0.5 l/m	
finishing (power loom)		0.5 l/m	
dyeing (hand loom)		0.5 l/m	
finishing (hand loom)		0.5 l/m	

Edible oil manufacture (organised sector)				
extraction			50	kcal/kg of seed
refining			140	kcal/kg of oil
Breweries				
brew making			0.876	kg/l of beer
boiling of wart			3.504	kg/l of beer
hot water preparation			0.876	kg/l of beer
bottle washing, etc.			0.876	kg/l of beer
Distillery			7800	kcal/l
Bulk drugs (antibiotics)	331 5	kcal/ kg		

Source: Chaturvedi and Kumar, 1990

Table 4: Estimates of process heat energy requirement for some manufacturing processes

Process	Energy form	Requirement t/t of product
Hydrogenation of oil	steam	0.50
Soyabean oil	steam	3.00
Cottonseed oil	steam	0.80
Soap	hot water	0.80
Sucrose	hot water	3.40
Industrial alcohol	steam	6.25
	hot water	12.50
Ethyl alcohol	hot water	12.00
Wood pulp	hot water	0.13
Sodium carbonate	steam	2.96
Urea	steam	2.00
Venyl chloride	steam	2.00
Nitric acid	steam	1.00
Oxygen	steam	1.75
Rayon yarns	hot water	48.00
Soda ash	hot water	1.60
Source: Industrial Energy Group, TERI		

The textile industry appears to be an attractive sector for solar thermal applications. The textile industry consumes about 8% of the total commercial energy in India. Of this about 80-90% is for thermal energy requirements and the remaining is for motive power (largely met by electricity). Hot water (below 90°C) is used for rope washing, kier boil, bleaching, cloth and yarn mercerising, dyeing drying, etc. in addition to boiler feedwater. Coal (for most mills except those in or near Bombay) and furnace oil meet the thermal energy requirements. The typical boiler efficiencies are in the range of 50-60% (TEDDY 1990/91, see also Table

5). The cotton textile sub-sector, which dominates the textile industry in India, is broadly divided into the organised and the unorganised (decentralised) sector consisting of the power loom and the hand-loom mills. The organised cotton textile sub-sector has about 700 mills (TEDDY 1990/91).

Table 5: Assumptions for computing the cost of CO_2 mitigation using solar flat plate collectors

Useful energy required for water at 80°C (ambient 20°C)	251 kcal/kg
Boiler efficiency	
with coal	55%
with fuel oil	70%
Calorific value of coal	5000 kcal/kg
Calorific value of fuel oil	10400 kcal/kg
Coal required for water at 80°C	0.091 kg per kg of water at 80 C
Fuel oil required for water at 80°C	0.035 kg per kg of water at 80 C
Solar collector cost	150 Rs/kg per day at 80 C
Lifetime of collector	10 years
Annual cost (capital and O&M)	41.55 Rs/year per kg of hot water per day
Annual cost of carbon saved	
coal	3.03 Rs/kg
fuel oil	6.69 Rs/kg

Cost of CO_2 mitigation with solar collectors

The assumptions underlying the estimation of the cost of avoided CO_2 using a flat plate collector to provide hot water at 80°C are listed in Table 5. As is indicated in the table, the cost for avoided CO_2 is Rs 3030 per tonne of C equivalent when the solar collector replaces coal as a fuel. The corresponding cost for fuel oil replaced in a boiler is Rs 6690 per

tonne of C equivalent. The higher figure for fuel oil is related to the higher useful energy delivered by fuel oil per unit of CO_2 released.

Based on the estimated requirement of hot water/ and or steam for different manufacturing processes in India (summarised in table 3 and 4), the potential avoided CO_2 for different products is listed in Table 6. Depending on the fuel substituted in the boiler, the tonne of C equivalent avoided per tonne of product is listed separately. The reason for lower amount of C equivalent offset for coal and fuel oil is the same as before - fuel oil delivers higher useful energy per unit of CO_2 released. As is evident form the table, the highest potential exist in the manufacture of bulk drugs, distillation and other process in the manufacture of alcohols, and in the textile industry.

Table 6: Potential for CO_2 in selected manufacturing processes in India

Process	Energy form	Requirement t/t of product	Carbon saving t/t of product	
			for coal	for fuel oil
Antibiotics	hot water	73.00	3.33	1.51
Rayon yarns	hot water	48.00	2.19	0.99
Synthetic drugs	hot water	15.00	0.68	0.31
Industrial alcohol	hot water	12.50	0.57	0.26
Ethyl alcohol	hot water	12.00	0.55	0.25
Sucrose	hot water	3.40	0.16	0.07
Soda ash	hot water	1.60	0.07	0.03
Cotton textiles (kg/-m2)	hot water	1.00	0.05	0.02
Milk	hot water	0.80	0.04	0.02

Soap	hot water	0.80	0.04	0.02
Wood pulp	hot water	0.13	0.01	0.00
Distilleries	steam	13.00	0.59	0.27
Brewery	steam	6.50	0.30	0.13
Industrial alcohol	steam	6.25	0.29	0.13
Cotton textile (kg/-m2)	steam	3.00	0.14	0.06
Soyabean oil	steam	3.00	0.14	0.06
Sodium carbonate	steam	2.96	0.14	0.06
Venyl chloride	steam	2.00	0.09	0.04
Urea	steam	2.00	0.09	0.04
Oxygen	steam	1.75	0.08	0.04
Bulk drugs	steam	1.18	0.05	0.02
Nitric acid	steam	1.00	0.05	0.02
Hydrogenation of oil	steam	0.50	0.02	0.01

Based on the assumptions listed in Table 5, the macro estimate of Jain (1978) and the indicated level of consumption of different fuels in the industrial sector of India, the total estimated potential for CO_2 avoided was approximately 26 million tonnes of C equivalent in 1991 (see Table 7).

Table 7: Estimated thermal energy consumption for Indian Industries

Fuel	units	Annual thermal energy use below 200 C		Carbon equivalent mt/y
		1978	1991	
	million t	20	37.7	18.85
oil	million t	2.5	4.7	2.82
Gas	billion cu.m.	1	1.9	0.76
Electricity	billion kWh	5.4	10.2	3.34
Total				25.77

Conclusions

The major conclusions of the analysis presented in this paper are as follows.

1. The cost for avoided CO_2 is Rs 3030 per tonne of C equivalent when the solar collector replaces coal as a fuel. The corresponding cost for fuel oil replaced in a boiler is Rs 6690 per tonne of C equivalent.
2. The highest potential exist in the manufacture of bulk drugs, distillation and other process in the manufacture of alcohols, and in the textile industry.
3. The total estimated potential for CO_2 avoided using solar hot water systems for industrial process heat was approximately 26 million tonnes of C equivalent in 1991.

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An overview of post-Rio political economy issues

Akshay Jaitly

Introduction

This paper attempts, in two parts, to examine some impacts of the United Nations Conference on Environment and Development at Rio de Janerio on particular political economy issues related to global environmental governance. Part I examines political economy implications of the Rio process through an analysis of the major documents originating from Rio.[5] It outlines some implications for major issues including sustainable development, sovereignty, the development of international law, the international economic system, financial mechanisms, the status of local and indigenous communities and the prescribed policy instruments.[6] Part II identifies the minimum requirements of a successful multilateral regulatory regime (the Convention-Protocol model) as identified by a number of analysts. Using information from Part I, the Rio regimes are compared with these in an effort to gain a preliminary view of their relative success and failure and an insight into their potential for the future.

The dual process of conflict and accommodation between contending positions taken by developed countries and developing countries in UNCED is evident from all the documents emanating from UNCED. This is perhaps best exemplified in the Rio Declaration which is portrayed as the international consensus on the future direction of global environment and development. Further, it is designed to give a more formal structure

5. Also, implications for transfer of technology and associated questions of the subsequent status of intellectual property rights are not being considered for reasons of scope.

6. The documents being considered are the Rio Declaration, the Framework Convention on Climate Change and the Biological Diversity Convention.

to the "global partnership" considered necessary to operationalize environmental imperatives related to development and growth. The Declaration provides a framework of values welded into an attempted integration, but the specific Conventions show up more clearly areas of conflicting interests. Apart from balancing these interests, local political, social and economic perspectives will also enter into the process of predicting the future scope of specific rules or principles outlined by Rio. The task is bound to be complex, and it is difficult to conceive of an easy unanimity in the results of the process.

The conventions examined

General comments - implications for international law

The Rio Conventions are a hybrid of two types in the commonly accepted taxonomy of treaties.[7] The first kind of treaty is of a norm creating character or forms the basis for the creation of a general rule of international law. The second establishes a collaborative mechanism for states to regulate or manage a particular area of activity. The norms that the Rio treaties are trying to create (in the context of the first type of treaty) relate to the acceptance of sustainable development as a fundamental principle of international economic and environmental organization. This forms the background of the UNCED process. More specifically, the individual treaties attempt to regulate particular types of activity that have implications for sustainable development. These are: the preservation of biological diversity and of the climate system. This second type of treaty is typically characterised as an international regime or as international administrative law. Within this framework, the treaties develop different mechanisms to address specific problems.

An important feature of the entire process is that it represents a new stage in the progressive development of international environmental law. The three Rio documents take up the thread of certain principles of

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7. For an elaboration of the different types of treaties and their relative application, see Henkin, Pugh, Schachter and Smit, *International Law, Cases and Materials*, Second Edition, West Publishing Co., St. Paul, Minnesota, 1989.

international environmental law and policy and have codified them in the context of the specific problems that they address. It would be naive, however, to imagine that ambiguities related to international environmental law have disappeared as a result.

Despite the fact that the **Rio Declaration** is non-binding, its worth as an international (legal) document cannot be ignored. The Declaration perhaps possesses the potential which the Universal Declaration of Human Rights (UDHR) did when it was adopted. The latter document provided the basic framework from which followed the International Covenant on Civil and Political Rights and the International Covenant on Economic Social and Cultural Rights, as also a host of declarations and conventions concerning specific human rights issues. The Universal Declaration, along with the two Covenants, are regarded today by a substantial body of responsible legal opinion as part of customary international law. If subsequent state practice roots itself in the Principles of the Rio Declaration, as can be expected, it may prove to be an important source of interpretation in the formulation of global environmental law and policy, and an important sector of customary international law could come into existence.

This is reinforced by the fact that the **Climate Change Convention** and the **Biological Diversity Convention**, which will become binding, contain Articles based on specific Principles in the Rio Declaration. Through the course of this paper we identify areas in which the Rio Declaration along with the Climate Change Convention and the Biological Diversity Convention are providing the impetus for the further development of emerging principles of international law. These include, as we shall see later in the paper, principles such as intergenerational equity, the right to development, the precautionary principle and the necessity of environmental impact assessments.

All the documents acknowledge human responsibility for causing the specific global environmental problem that they address. Also, the message of the Rio process is quite clearly anthropocentric. Only the concerns and rights of humans are implicated and there are no provi-

sions for rights of animals or any other living or non-living entities. We now turn to an examination of specific political economy issues.

Sustainable development

Sustainable development constitutes the stated goal of the UNCED process. However, an analysis of the documents reveals that they provide no clear definition of the concept of "sustainable development" and that sufficing interpretations have to be drawn from the texts. The literature on the meaning and content of sustainable development is too extensive to review here, but a brief statement may be essayed.

Definitions

The most widely accepted definition of sustainable development is provided by the UN's World Commission on Environment and Development, which described it as development that "meets the need of the present without compromising the ability of future generations to meet their own needs" [World Commission on Environment and Development: 1987]. This articulation of sustainable development has led to attempts to spell out in greater detail the specific features of this concept. Some alternative definitions that outline the content of sustainable development are given below.[8]

An economic definition places greater emphasis on the use of "renewable natural resources in a manner that does not eliminate or otherwise diminish their...usefulness for future generations".[9] Alternatively, in a welfare state perspective, sustainable development has been described as development that improves health care, education and social

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8. These are based on definitions provided in World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1992.

9. Robert Goodland and George Ledec, "Neoclassical Economics and Principles of Sustainable Development," *Ecological Modelling* Vol 38 (19870 p 36. Quoted in *World Resources 1992-93.*

well being.[10] A third, technology based interpretation is that sustainable development includes a "rapid transformation of the technological base of industrial civilization"[11] with the use of new technologies that should be cleaner, more efficient and less natural resource intensive.[12] An ecological definition of the concept is that it involves "improving the quality of human life while living within the carrying capacity of supporting ecosystems".[13]

There do, of course, exist linkages between each of these concepts \interpretations of sustainable development, which indicate that these could be considered aspects of the same process. These definitions are intended to be merely pointers in terms of content and not a description of the debate on the subject.

Interpretations

The Rio Declaration contains numerous references to sustainable development. In the absence of an explicit definition, a proximate interpretation can be derived through an examination of the text of the various Principles.

Its implicit contents may be some or all of the following:

(a) "a healthy and productive life in harmony with nature," (Principle 1);

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10. United Nations Development Programme, *Human Development Report 1991*, Oxford University Press, New York, 1991. Quoted in *World Resources 1992-93.*

11. James Gustave Speth,"The Environment: The Greening of Technology," *Development*, Vol.2, No.3, 1989. Quoted in *World Resources, 1992-93.*

12. George Heaton, Robert Repetto and Rodney Sobin, *Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century*, World Resources Institute, Washington D.C., 1991. Quoted in *World Resources 1992-93.*

13. IUCN-the World Conservation Union, United Nations Environment Programme and World Wide Fund for Nature, *Caring for the Earth*, IUCN, UNEP and WWF, Switzerland, 1991. Quoted in *World Resources, 1992-93.*

(b) "environmental protection is an inherent part of the development process,"(implying perhaps that development that does not protect the environment is not sustainable) (Principle 4);

(c) "eradicating poverty," (which is seen as an indispensable requirement for sustainable development) (Principle 5);

(d) as related to "production and consumption," and "appropriate demographic policies," (Principle 8) and;

(e) involving "exchanges of scientific and technological knowledge, and by enhancing the development, adaptation and diffusion of new technologies, including the transfer of technologies" (Principle 9).

In line with the different definitions listed in Section 2.1 above, (a) and (b) could be said to represent the environmental or ecological aspects of sustainable development, (e) involves the technological component and (c) and (d) relate to the economic and human aspects. Developing country concerns around the UNCED process have predominantly related to (c) and (e).

Poverty eradication is a priority in developing countries and the focus of most development measures. The Climate Change Convention and the Biological Diversity Convention both explicitly recognize that economic and social development and poverty eradication are the first and overriding priorities of developing countries with respect to the fulfilment of their commitments under the Conventions.

The importance of the technology transfer issue is obvious from the protracted wrangling over the Climate Change and Biological Diversity Conventions. The developing country argument, as is well known, has been that to follow sustainable development paths and to fulfil obligations that may arise under the two conventions, the transfer of funds and technology are essential. The crux of the post-Rio environmental debate will relate to the mechanisms to deal with poverty eradi

cation and transfer of technology.[14]

Likewise, the two conventions contain references to sustainable development. The Climate Change Convention describes sustainable development is described as requiring "access to resources" (Preamble), and recognizes that sustainable development for developing countries means an increase in energy consumption. It states that all countries have the right to and should promote sustainable development (Article 3 (4)) and also holds that an open and supportive economic system would lead to sustainable development in *all* countries, especially developing countries. This is hard to swallow. First, it can be argued that a commitment to using more resources contrasts with the WCED definition of sustainable development, which aims to minimize the use of resources. Second, as will be discussed later, it is difficult to imagine that there would be no losers whatsoever (at least in the short run) as a result of instituting an open and supportive economic system. (See Section 4 below).

The Biological Diversity Convention is fundamentally based on promoting the sustainable *use* of the components of biological diversity. This is defined as "the use of the components of biological diversity in a and at a rate that does not lead to the long term decline of biological diversity, thereby meeting its potential to meet the needs of present and future generations" (Article 2).

The cumulative message from Rio as related to sustainable development is generally in keeping with the WCED interpretation. It is however entirely possible that national and international efforts to bring about sustainable development will lead to changed interpretations and a sharper focus on the issue. A close reading of Agenda 21, which intends

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14. The debate over mechanisms relates not only to institutions that will be set up to oversee the Rio agreements, but also over the appropriate policy instruments for the process. Developed countries are likely to argue that market friendly mechanisms and respect for intellectual property rights are essential, while developing countries will argue in favour of easy access to technology and the right to determine the appropriate domestic regimes to operationalize sustainable development policies.

to spell out the contents of a global sustainable development policy will be required to determine possible conflicts (in the context of both Conventions) with existing notions of the concept and with (potentially non-sustainable) development in general, since difficult choices, manadated by scarce resources, will probably have to be made at a later stage.

Intergenerational equity

The concept of intergenerational equity has as its basis a determination of the obligations of current generations to future generations and, consequently, the rights of current people to use resources available on the earth. This requires a focus on the relationship that each generation has to others. To define the notion of intergenerational equity, it is helpful to view the human community as a continuous partnership across all generations, whose purpose is to realize and protect the well being of every generation and to conserve the resources of the planet for this purpose. The Rawlsian notion of the "veil of ignorance" implies that each generation will want to receive the planet in at least as good condition as every other generation.[15]

Intergenerational equity can also be defined in terms of intergenerational (intertemporal) externalities [Rowe: 1991]. An intertemporal externality would be one which involves benefits accruing to the present generation, reaped at the cost of future generations (and, possibly, the other way around as well). It is the imposition of a cost at a time later than the time at which the benefit is received.

Two kinds of equity are embodied in the WCED definition of sustainable development quoted in Section 2.1. The first is equity for people living now, who do not have access to natural resources or social and economic goods; and the second is intergenerational equity as defined above. There exists the potential for conflict between these two notions, especially since the two Conventions do not always draw clear

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15. For an elucidation of the concept of a veil of ignorance, see John Rawls *A Theory of Justice*, Harvard University Press, Cambridge, MA, 1971.

distinctions between them. Equity, therefore, is an obvious subject for future protocols.[16]

Some analysts point out that environmental issues in developing countries cannot be resolved without alleviating poverty, and call for redistribution of wealth and incomes spatially, both within countries and between rich and poor nations. Others stress intergenerational equity and focus on the need for reducing current consumption to provide for investments that build up and maintain resources for the future. Despite the fact that sustainable development implies, primarily, intergenerational equity, it is necessary to be aware of the ways in which uncorrected interspatial equities may mask or contribute to the existence of intertemporal equities [Rowe: 1991]. Where spatial inequities are not prevented, or at least compensated for, societies tend to be unaware of possible intertemporal inequities and the capacity of institutional structures to prevent them are likely to be absent.[17]

The Rio documents seem to follow the line of argument that it is possible (and necessary) to do both. In calling for transfers of financial resources across nations, they try to address the issue of equity between nations (though not *within* nations). At the same time they all stress the need for intergenerational equity, both in terms of their embracing the concept of sustainable development and more explicitly, in their reference to intergenerational equity itself. This is done in the following manner.

Principle 3 of the Rio Declaration states that the right to development must be fulfilled so as to meet the developmental and environmental needs of present and future generations. In the Climate Change Convention intergenerational equity is referred to both in the Preamble and in Article 3 (1), in the context of the protection of the climate for present and future generations. Likewise, in the Biological Diversity

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16. For reasons of scope, we do not discuss details of various equity formulations in this paper.

17. A person intent sloely on providing for basic needs is unlikely to be aware of his or her contribution to degrading resources that are necessary for use in the future.

Convention, this temporal form of equity is referred to in the Preamble, which resolves to conserve and suitably use biological diversity for the benefit of present and future generations. Further, in Article 1, the sustainable use of biological diversity -- both in terms of needs and *aspirations* -- is defined in terms of intergenerational equity. This could perhaps be interpreted as further delineating the concept of intergenerational equity, introducing a greater subjective element, since "aspirations" could prove extremely difficult to define.

The right to (sustainable?) development

There are two moral and political imperatives behind the right to development itself which are based in the history of North-South political economy.[18] The first of these can be traced back to United Nations General Assembly (UNGA) Resolution 626 (VII) of 21 December 1952, which referred to the right of member states freely to exploit their natural resources, and is based on the principle that the individual State should have the right to control its own economy and thus develop in its own way. The second imperative is the idea that economic development as such that inadequate and the performance of an economic system should be related to qualitative criteria based on human rights standards as well. Our analysis looks at the effect that UNCED may have had on the first set of imperatives relating to the right to development an will not refer to the latter.

The credit for the formulation of a *formal* right to development belongs to an eminent Senegalese jurist, Keba Mbaye, writing in 1972. By 1979, the Commission on Human Rights of the Economic and Social Council (ECOSOC) of the United Nations had begun studying the right to development and in 1986 the UN had adopted a Declaration on the Right to Development based on the report of the Commission. The legislative history of the right is thus firmly based within the human

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18. This section draws on Ian Brownlie, "The Human Right to Development," *Commonwealth Human Rights Unit Occasional Series*, Commonwealth Secretariat, London, 1990, for the history of the right to development.

rights agenda of the General Assembly and ECOSOC, two UN bodies traditionally dominated by developing country interests.

The December 1986 UNGA resolution contained an annex with a "Declaration on the Right to Development" which spelt out the details of the content of the right to development. Elements of the right were held to be the following: the right of peoples to self-determination, the right of peoples to full sovereignty over their natural wealth and resources, an element of international economic justice, people- oriented development, development assistance and consequently the flow of funds from richer to poorer nations, international cooperation, disarmament and popular participation in the decision making process. This Declaration is not the only source of interpretation of the right to development but supporting evidence of the content is provided by a number of other international documents.[19]

The process of global environmental governance may be altering the content of the right to development. In stressing sustainability and intergenerational equity, the focus seems to be shifting from equity between present people (in different nations or in different parts of an individual nation) to include intergenerational equity. Developing nations need to be careful that this interpretation does not come to dominate the international environmental arena, and that issues relating to international inequities do also remain an issue on the agenda.

Sovereignty

One of the principal concerns of developing countries in the global environmental process has been to prevent any international jurisdiction over of what are considered national natural resources. This has been an important aspect of their position for a number of years. The Principles of the Stockholm Conference on the Human Environment declared that states have the "sovereign right to exploit their own resources, pursuant to their own environmental policies and the responsibility to ensure that activity within their own jurisdiction or control do not cause damage to

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19. See for instance, the Charter of the Organization of African Unity.

the environment of other states or of areas beyond the limits of national jurisdiction" [Rowe: 1991]

While today the use of these resources is important mainly in the context of their economic value and exploitation, the depth of sentiment in developing countries on this issue must be seen against the backdrop of their shared colonial experience. This is the perception that many of their current economic problems (poverty, debt, low international commodity prices etc.) can be traced to policies of colonial regimes, which exploited the natural resources of colonial territories for their own advantage and deprived those territories the opportunity of self-development.

Another argument is that for states to be equal players in a global partnership, it is essential for them to have independent natural resource exploitation policies. This exercise of their sovereign rights, it is felt, is the only way to ensure their meaningful participation in any global process. They believe that the right and opportunity to exercise an autonomous exploitation of their own natural resources is a powerful factor in the maturation of a people to the full dimensions of Statehood. These concerns were brought to Rio by developing countries.

A natural corollary to this perspective on sovereignty is the concern that international jurisdiction over natural resources should supplement and not supplant national controls. Further, that inclusion of global perspectives in the formulation of national economic policies should not necessarily imply the supersession of autonomous national control by any form of international jurisdiction.

This classic developing country concern is addressed in each of the Rio documents.[20] The sovereign right of States to exploit their own resources, pursuant to their own environmental and developmental policies..." is clearly acknowledged in the Rio Declaration. The wording of this principle, however is not unambiguous. States are recognized as

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20. In Principle 2 of the Rio Declaration, the Preamble in the Climate Change Convention and Article 3 of the Biological Diversity Convention.

possessing sovereign rights over their "own resources", without any details of what these include. It becomes especially necessary to define "own resources" because things like the atmosphere, earlier considered unlimited free goods, have become scarce in the context of GHG accumulation. The enjoyment of these sovereign rights are limited only by consideration of their transboundary environmental impacts. It is possible to interpret this principle as defining the limits of "own resources," i.e. resources cease to be national to the extent that their exploitation can have adverse transboundary impacts.

A cautionary note needs to be sounded with reference to the sovereignty principle. While the existence of national power over natural resources is an important principle of international law, it must be recognized that any process of cooperative international decision-making requires, almost by definition, a degree of sacrifice of sovereign rights by states parties.

The Conventions recognize the fact that the activities being regulated lie within the realm of national jurisdiction. However, even the presence of non-binding exhortations to change this pattern of activity and to cooperate in international efforts can have the effect of restricting sovereignty. While most measures envisaged in the two Conventions depend on individual state action, states are under an implicit obligation not to carry out activities that go against the spirit of each convention, even if such activities are otherwise legitimate. The primary method of enforcement of such a principle is "peer pressure" exerted by other nations that are part of the same treaty arrangement. It is also important to note the impact of the differential power of states in the international arena on this process.

More specifically, in the Climate Change Convention, commitments envisaged under Article 4 (1) and (2) envisage nations altering patterns of development and lifestyles, moving to less GHGs intensive paths. To accept this implies some restrictions, voluntarily executed, but internationally determined. This is specifically true of developed country commitments under 4 (2), where a specific target of returning to 1990 levels by the end of the decade is alluded to. Again, while this is not a

binding commitment, the existence of a specific number and date puts pressure on states to follow it.

In the Biological Diversity Convention it could be said that sovereignty could be affected due to the promise of access to biotechnology. Sovereign rights will be given up, albeit in a contractive framework that. Article 16(1) states that access to resources is essential for the success of the convention, which can be copnstrued as an implicit encouragement to give up sovereignty.

The international economic system

Global economic inequities have been part of the North-South political economy debate since the process of decolonization began after World War II. Traditional developing country demands for a new international economic order (NIEO) have diminished, but fears of economic imperialism linger and must be addressed by any process implicating the global economy.

One of the main (stated) priorities of developed countries is to move towards an international economic system that encourages or at least allows (if only in principle) free trade and access to foreign investment (especially in developing countries). While the necessity of global partnerships and assistance to developing countries is accepted in principle, there is a concern among developed countries that the possible changes in lifestyles, the "new and additional flows" necessary to enable developing countries to carry out environmentally sound development measures and the internalization of environmental costs to the polluter will distort current patterns of international trade and investment.

The meaning of an "supportive and open" international economic system (which is held to promote economic growth and sustainable development in all countries) is also of potential importance to developing countries. Supportive could variously be interpreted as supportive to developing countries, implying concessional aid, technology transfer, easier access to markets and the like. On the other hand supportive as interpreted by developed countries could mean an economic environment within developing countries that would support direct foreign invest-

ment, allowing easy access to exports and conforming to developed country intellectual property rights. Likewise, "open" could be interpreted to mean open economies with free trade and direct foreign investment or, on the developing country side, easier access to technology and the removal of tariff and non-tariff barriers. Developing countries, therefore, are concerned that an operational interpretation of "open and supportive" does not lead to unfavourable terms of trade and investment and does not attenuate their economic sovereignty.

There is some ambiguity involved in the wording of Principle 16 of the Rio Declaration, which also finds expression, in a slightly altered form, in Article 3 (5) of the Climate Change Convention. In this principle, national authorities are encouraged to promote the internalization of environmental costs and the use of economic instruments, on the basis of the polluter pays principle discussed below. At the same time nations are urged to do so without distorting international trade and investment. If the meaning of "distort" in this formulation is loose and refers to deviations from the "rules of the game" (i.e. free trade and an open investment climate), then the Principle has some meaning. If, on the other hand, the interpretation is a strict economic one, then it is difficult to understand how distortions will not take place as a result of changes in comparative advantage that will come about as a result of changed cost structures (as a result of the internalization of environmental costs to the polluter/producer). These issues will require resolution in the future.

Financial mechanisms

One of the most crucial questions that Rio poses is that of the structure and functioning of the international financial mechanism that will oversee financial transfers envisaged in the two conventions. This is so particularly because of the problem of developing country debt problems and repayment issues that loom large over international relations in this area.

In the Climate Change Convention, Article 11 (1) defines a mechanism for the provision of financial resources on a grant or concessional

basis. This is to be accountable to the Conference of the Parties established under the Convention. The Conference of the Parties is to decide its policies, programme priorities and eligibility criteria. The Article goes on to say that the operation of the mechanism will be entrusted to one or more *existing* international entities.

Paragraph (2) of the same Article states that the financial mechanism shall have an "equitable" and "balanced" representation of all parties within a "transparent" system of governance. This is crucial because the extent of say that different groups of countries (developed and developing) will have over the disbursement of funds related to the financial mechanism and the basis on which lending will be carried out hinges on it. Developing countries will be eager to ensure that the functioning of the financial mechanism does not allow donors to direct and determine economic priorities (a la structural adjustment) in the countries they lend to through the FM. There is therefore a need to clarify the exact meanings of the terms in quotes above. Article 21 deals with interim arrangements for the FM and envisages that the Global Environmental Facility (GEF) of the World Bank, UNDP and UNEP will be the international entity entrusted with this task. For the GEF to carry out this role in accordance with the guidelines in Article 11, its restructuring, with membership becoming universal.

Similar arrangements exist in the Biological Diversity Convention. Article 21 (1) states that the Conference of the Parties shall determine the policy, strategy, programme priorities and eligibility criteria relating to access and use of financial resources collected under the Convention. It envisages that the mechanism shall operate within a "democratic" and "transparent" system of governance. Article 39, on interim financial arrangements, again designates the GEF with the job. It specifies that the GEF must be fully restructured in accordance with the requirements of Article 21.

The financial mechanism and the restructuring of the GEF has implications for the process of decision making in the international arena. Thus far the GEF has functioned as a part of the World Bank system, with weighted voting on the basis of the number of shares held

by members. This introduces an inherent bias in the system towards developed countries, especially the United States, which hold the majority of shares. The future structure of the GEF will have to be fine tuned in order to accommodate developing country concerns outlined above; this again could be the subject of a future protocol. It will also have to be designed in a manner that will ensure continued participation of the United States and other intransigent donor countries, who will obviously prefer the World Bank system for weightage according to contribution.

Indigenous and local communities

Some interested parties (especially representatives of various indigenous communities and their organizations that gathered in Rio in the parallel Global Forum) would consider that the greatest failure of the Summit (and the Conventions that came out of it) was its inability to safeguard concerns of indigenous and local communities relating to their community resources and practices. A number of aspects of traditional lifestyles are implicated by the issues discussed at Rio. The treaties fight shy of accepting traditional rights, and leave this issue to the discretion of governments, which may not act in the interests of these communities.

Rio Declaration acknowledges that indigenous peoples and their communities and other local communities have a vital "role" to play in environmental management and development because of their knowledge and traditional practices. Further it says that states should "recognize" and duly "support" their identity, culture and interests and "enable" their effective participation in the achievement of sustainable development. Note that there is no mention of any *rights* nor does the Declaration explicitly prohibit activities that may harm traditional ways of life.

The Biological Diversity Convention implicates such traditional communities far more directly than either the Rio Declaration or the Climate Change Convention. Genetic resources (or the living matter that contains them) are often an integral part of life in these communities and regulatory attempts are extremely likely to affect traditional uses of these resources. The Biological Diversity Convention, in its Preamble, recognises the close and traditional dependence of many indigenous and

local communities embodying traditional lifestyles on biological resources and the desirability of sharing equitably the benefits arising from the use of traditional knowledge, innovations and practices relevant to the conservation of biological diversity and the sustainable use of its components.

Article 8 (j) encourages states, "subject to national legislation", to respect, preserve and maintain knowledge, innovations and practices relevant to the conservation of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from utilization of such knowledge, innovations and practices. Further, Article 10 (c) urges states to protect and encourage the customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements.

Also, 10 (d) encourages states to support local populations and develop and implement remedial action in degraded areas where biological diversity has been reduced. Finally, the contracting parties are encouraged, in accordance with their national legislation and policies to encourage and develop methods of cooperation for the development and use of technologies, including indigenous and traditional technologies of the objectives of the convention. The language throughout is dilute.

The words used: "respect" "promote", "protect" and "encourage", contain no strong directives to states parties to actually incorporate measures that take into account the interests of traditional communities. This is an area of weakness in the Rio process. Traditional communities have in the past been adversely affected by development projects, especially those with significant environmental impacts. At the same time, there is an expanding consensus about the value of the knowledge systems developed in these traditional communities, which revolve around the sustainable use of resources available in their environment. Much of this knowledge and information has not been documented or recorded as yet. The principle of scientific uncertainty could have been extended to apply to indigenous knowledge, and this could contain clues

as to useful applications. Also, if events in the recent past are any indication, local communities can organize in resistance to development projects that they feel go against their interests. Any far sighted policy maker would be well advised to consider the interests of these communities in framing policies and implementing projects that implicate these communities.

Anticipated policy instruments

We look here at the extent to which the conventions further the progressive development of international regulatory instruments for the control of the environment. Legal liability regimes, economic regulation and environmental impact assessments are envisaged as possible instruments in the Rio Declaration (Principles 13, 16, 17 respectively), though not all instruments are emphasised in each Convention.

Polluter pays principle

In the Rio Declaration the polluter pays principle is stressed both in terms of the development of national laws of liability and compensation and the development of economic instruments. The idea behind the principle is to internalize the costs of pollution to the polluter. Principles 13 and 16 specifically address legal liability and economic instruments, respectively, though no mention is made of how an appropriate choice would be made between the two. The selection of a particular instrument can have deep implications for developing countries, since they place differing burdens of responsibility and cost on them.[21]

The Climate Change Convention does not explicitly accept polluter pays. There are implict indications that this concept is at play. The Preamble notes that the largest share of GHG emissions originated in developed countries, and throughout the document, "common but differentiated responsibilities" are referred to in addition to capabilities. It

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21. See Ghosh and Jaitly, Legal Liability Vs. Administrative Regulation: the Problem of Institutional Design in Global Environmental Policy, paper presented in this Seminar.

could perhaps be construed that these outlined on the basis of a historical polluter pays principle for GHG accumulation. The Biological Diversity Convention contains references to liability in the case of harm caused due to the release of a genetically modified organism as under Article 8 (g) and (h). Article 14 (2) empowers the Conference of the Parties to examine the issue of liability and redress, including restoration and compensation, for damage to biological diversity, except where such liability is a purely internal matter. For both Conventions, more sophisticated liaiblity instruments could be developed as a protocol.

Information and notification

Principles 18 and 19 of the Rio Declaration refer to information and notification requirements in case of transboundary environmental harm. The issues addressed by these principles appear to be far more dilute than what may be mandated by environmental realities. Principle 18 for instance, requires states to notify other states of any natural disasters or other emergencies that are likely to produce *sudden* harmful effects on the environment of those states.

Further, the international community is enjoined to make every effort to help states so affected. The language of the principle is ambiguous. What is implied by "other emergencies" is unclear. If disasters such that at Chernobyl is the target, then the principle has some value, otherwise, it remains fairly toothless. Secondly, the international community is only required to make "every effort" to assist the affected states, with no firm commitment necessary to repair damage.

The interpretation of Principle 19 depends, to a great extent on that of 18. In it, states are required to provide "prior and timely notification and relevant information to potentially affected sates on account of activities that may have a *significant adverse transboundary impact* and to consult with those states at an early stage...". The meaning of the phrase in italics hinges on what was meant by "other emergencies" in the Principle 18. If this addressed the Chernobyl type situation, then it could perhaps be assumed that Principle 19 is aimed at activities that

contributed to other (global) environmental problems that are slower to develop (such as climate change).

In the Biological Diversity Convention, Article 14 (1) (c), (d) and (e) deal with similar information and notification requirements. Article 14 (1) (c) encourages the states parties to promote, on a reciprocal basis, the exchange of information, notification and consultation on their activities "that are likely significantly to affect adversely the biological diversity of other states or areas beyond their jurisdiction". Clause (d) of the same Article enjoins states to immediately notify potentially affected states of threats to their biological diversity in the case of grave or imminent danger or damage originating under their control.

The requirements under the Rio Declaration is merely for states to notify, inform and consult, with no mention made of methods to solve the problems created by such activities. This can set a dangerous precedent for future environmental policy making based on the Rio Declaration. In the Biological Diversity Convention, however, clause (d) enjoins states to initiate action, in addition to information and notification requirements, to prevent or minimize such danger or damage.

Environmental impact assessments

Environmental impact assessments (EIAs), already a part of environmental language and policy all over the world, are also strongly recommended as a policy instrument by the Rio Process.

Principle 17 of the Rio Declaration advocates the adoption of EIAs as a national instrument, for activities that are likely to have a significant adverse impact on the environment. These are to be made subject to the decisions of a competent national authority. The Climate Change Convention refers to EIAs in Article 4 (1) (f), which refers to the introduction of climate change considerations in policy formulation. It may be significant that EIAs are the only instrument specifically mentioned as an "appropriate method" to minimize the effects of climate change on the economy, public health and environmental quality. Article 14 of the Biological Diversity Convention encourages contracting parties to introduce appropriate procedures requiring EIAs on projects that are

likely to have a significant adverse effects on biological diversity, and, further, allowing for public participation in the process.

Successful international regimes

Was Rio a success? Did concerned parties come away with what they were looking for? A basic condition for the success the arrangement is political acceptability. This, at the risk of stating the obvious, forms the basis for the successful conclusion of any negotiated process and each of the features listed below help in making the convention politically acceptable.[22] We identify here six features considered necessary for the success of an international regulatory regime and see how the Rio Conventions compare with these.

Flexibility

A Convention-Protocol model of international regime must be flexible in its ability to deal with, among other things, scientific uncertainty and different national concerns.

Both Conventions recognize different groups of countries, based primarily on varying types of national concerns. The primary classification of countries is on the basis of the developed/developing country distinction. This divides the signatories into two distinct groups, with different sets of commitments. Developed country commitments are somewhat more stringent and are implicitly based on first, their respon-

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22. Details of what the features of a successful convention should be were gleaned from, amongst others, the following articles: Ajay Mathur, "Political Issues in the Formulation of a Climate Change Convention," paper presented at the Global Forum, Rio de Janerio, June 1992, Ligia Noronha, "Background Note on the INC Negotiations," Tata Energy Research Institute, New Delhi, 1991 James Sebenius, "Designing Negotiations for a Successful Regime," *International Security*, Spring 1991 (Vol 15, No.4) and Oran Young, "The Politics of International Regime Formation: Managing Natural Resources and the Environment, *International Organization*, Vol 43, No.3, 1989.

sibility for causing the problems and, second, their ability to pay for measures to solve them.

A secondary set of classifications is on the basis of more specific characteristics, such as those dependent on fossil fuels as users, producers, exporters and importers and countries that, for different reasons, are considered more susceptible to the negative impacts of global warming or the loss of biological diversity. These include least developed countries, small island states, countries with low lying coastal areas, those in semi-arid regions, or those with fragile mountain eco-systems. One of the reasons behind this method of classification could have been to provide the flexibility required for different countries to sign and, further, to adhere to their commitments.

As mentioned above, it is also important that any arrangements to deal with climate change and the loss of biological diversity take specific account of the prevailing uncertainty. This will enable future responses to be tuned to deal with possible changes in the associated scientific facts, given an adequate review mechanism.

Article 4 (2) (d) of the Climate Change Convention provides for the review of developed country commitments in the light of best available scientific information. Based on this, the Conference of the Parties can take appropriate action, including recommending amendments to the Convention. Article 7 (2) (a) enjoins the Conference of the Parties to "periodically examine the obligations of the Parties and the institutional arrangements... " in line with the "evolution of scientific and technological knowledge. In the Biological Diversity Convention, similar arrangements exist under Article 23, which gives the Conference of the Parties the task of review, on the basis of, in paragraph (b) of the Article, scientific, technological and technical advice. The process, therefore, does allow for sufficient flexibility.

Inclusiveness

For a comprehensive solution to global problems with multivariate causes, a convention must look for inclusiveness: of actors, of all the sources of the problem being addressed and of possible solutions.

One of the features of the Convention-Protocol model of international agreements in which universality is desired, is that in an effort to appeal to a wide group of countries, principles often have to be diluted; this has been called the "lowest common denominator" [Sand 199*]. This can reduce the value of the treaty arrangement as a whole. If, on the other hand, this is not done, it can be expected that some countries -- or groups of countries -- will not become part of the treaty arrangement.

The Rio documents have suffered from both the above problems. The Declaration attempts to be all things to all people, perhaps because it is a declaration and not a convention, and also because it purports only to provide a framework to guide environmental law and policy making in the future. In the Climate Change Convention, it was hoped that developed countries would arrive at specific (CO_2) emissions reduction targets. United States refusal to accept such targets consigns the subject to the realm of a future protocol, even though some nations might adopt unilateral reduction targets. In the Biological Diversity Convention, despite the presence of weak and mitigating language, the United States refused to accept provisions relating to the transfer of biotechnology and associated implications for intellectual property rights and did not sign the Convention. This significantly detracted from its value and the failure to include the United States is one of the primary weaknesses of the process.

It is also necessary a convention cover all the sources or activities that cause the problem being addressed. In the Climate Change Convention all activities generating all types of GHGs (except those covered by the Montreal Protocol i.e. CFCs) are covered and no differentiation is made between different sources of GHGs. The Biological Diversity Convention refers to the protection of all sources of biological diversity.

Accommodating domestic constraints to international cooperation

Countries can face a number of purely domestic constraints to international cooperation that may emerge from a number of factors. These could reduce their ability to contribute to and participate effectively in implementing the rules and mechanisms established under the regime. These constraints need to be accommodated.

Global environmental issues are not generally the subject of popular debate in developing countries, primarily because of the pressures they face from the requirements of development itself. Such pressures can include growing populations, low standards of living and various other social and economic problems. The imperatives of development are recognized throughout the Conventions, and as we have seen in Part I, the right to development has been strongly reaffirmed, though in the altered garb of sustainable development. In the Climate Change Convention, the Preamble recognizes that energy consumption in developing countries will grow to meet the needs of social and economic development. The extent to which development concerns will predominate over environmental ones under the Convnetions remains to be seen

Interest groups within each country have a role to play in the run-up to a country's ratification of a convention. This is particularly true if the regulated activities are likely to have a significant effects on the domestic economy and lifestyles. These groups, if powerful enough, can affect the stability of governments, cause major changes in policy orientation and form coalitions that could make the domestic functioning of a treaty regime extremely difficult.

With respect to the Climate Change Convention, the major interest groups that could be negatively affected by its ratification include oil and coal producing companies, power producing utilities and GHG emitting industry in general. The Convention therefore fights shy of setting specific targets for emissions reduction -- something that would seriously affect these groups -- and instead seeks to accommodate the positions of powerful lobbies such as oil companies, by referring instead to the need to cater to the interests of *countries* (oil-dependent, producers, exporters) that would be affected by international GHG emissions standards.

In the Biological Diversity Convention, the main industrial interest groups with a stake are pharmaceutical companies and other biotechnology patent holders. These groups have had a large role to play in the United States' non-ratification of the Convention. These groups feel that the transfers of biotechnology envisaged under the Convention would compromise resources invested in R&D. The Bush Administration

position on the Convention, in line with the above thinking, has therefore been that it affords inadequate protection to the holders (current and future) of intellectual property rights.

Another group whose interests will be affected by the Biological Diversity Convention are indigenous and local peoples. However, as we have seen, these groups have not gained any major benefits under the Convention, and some analysts would point out that their position could be worse after the Biological Diversity Convention comes into force. These interest groups, however, have less leverage on their governments, which, therefore, feel that they can be sidelined.

Enhancing the scientific and technical capabilities of developing countries can also enable a country to meet its commitments under a Convention. The Climate Change Convention, in Article 4 (1) (g) and Article 5 refers to such capacity enhancement. The former refers to the necessity of promoting scientific and other research related to climate change and clause (c) of the latter enjoins Parties to "take into account the particular concerns and needs of developing countries and cooperate in improving their endogenous capacities and capabilities" and, to participate in efforts related to support and develop international and intergovernmental efforts to deal with climate change.

Politically acceptable rules

The actions prescribed by a Convention-Protocol model have to be acceptable and lie within the realm of practical possibility. It is therefore necessary to define at the outset the distribution of rights and responsibilities arising from the conventions.

In the case of the Climate Change Convention, this translates into possible future resource transfers, which harkens back to the question of intergenerational vs. spatial equity. Developing countries were concerned that in focusing on the needs of future generations, current perceived imbalances in global patterns of production and consumption will be ignored in measures for the protection of the environment. In this framework, it was claimed, there was no scope to do anything for

external indebtedness and the eradication of poverty.[23] The Climate Change Convention deals with the issue by giving poverty eradication and other development concerns an important place as a basic principle, while at the same time referring to the necessity of providing for inter-generational equity. The spatial equity issue, however, is not adequately dealt with and will undoubtedly need addressed in a subsequent protocol.

At the same time, there should be no *perception* of infringement of national sovereignty as part of the process, even if in reality some sovereign rights have to be given up. Sovereignty is reaffirmed as a guiding principle and the success of the conventions is made contingent on national enforcement. However, as we have seen, the Conventions limit sovereignty in various implicit ways, but evidently this has not been sufficient to deter most countries from signing the Conventions. Thus, as we have seen, Rio has had mixed success in framing politically acceptable rules.

Transparency

To be credible and to increase signatory confidence, any international arrangement has to be transparent, with actions under it open to scrutiny and debate. In the case of the Climate Change Convention, transparency is required in the accounting of GHGs emissions, the steps taken to control them and evaluations of the efficacy of these steps. Mechanisms exist for review by the Conference of the Parties, and national inventories of GHGs and steps taken to address the problem have to be regularly published. The Biological Diversity Convention could face problems relating to transparency. The requirements of disclosure in the treaty are restricted to the country providing genetic material and the country receiving it in order to develop biotechnologies. This allows for situations where the country developing the biotechnology to exploit this asymmetry due to its stronger position with respect to information and resources.

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23. Indian position paper on global environmental issues.

Transparency is also essential in the working of the financial mechanisms that fund activities related to a Convention. In the case of the Conventions being examined here, the Global Environmental Facility is the financial mechanism designated to effect the allocation and distribution of funds, on the condition that it be made transparent. It remains to be seen how this is done, because thus far, no details of how transparency will be brought about have been discussed in the document.

Issue linkages

Issue linkages are considered essential in order to demonstrate the common advantage of adhering to a convention and later to a protocol to the different parties involved.[24] The history of negotiations relating to the 1958 Law of the Sea Conference (LOS) illustrated the necessity of establishing issue linkages. The package relating to the 1958 Convention envisaged three "mini conventions" that dealt with specific issues. The disadvantage of such a process is that states can choose to adhere only to those conventions that leave them with a net advantage. This in turn leads to disagreement and confrontation and ultimately - in the case of the 1958 LOS - to failure. For countries or groups of similar countries a single issue represents a clear gain or loss and therefore may prove non-negotiable, unless it can be combined with agreements on other issues that offset the losses. In the latter case, there may exist the possibility of an "exchange" around issues for joint gain.

Issue linkages form part of both the conventions and also find a place in the Rio Declaration. To start with the latter, some of the issue linked are population with production and consumption. On the one hand, developing countries have been concerned that their high population growth rates should not bear primary responsibility for global environmental problems. On the other hand, developed countries are reluctant to accept changes in lifestyle patterns that would be made necessary if what has been described as their "unsustainable" patterns of

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24. See James Sebenius, "Designing Negotiations Toward a New Regime," quoted above.

production and consumption are made the primary focus of environment and development problems. Principle 8 of the Declaration links the two in the following manner: in order to achieve "sustainable development and improve the quality of life for all people" it recommends that states should reduce and eliminate unsustainable patterns of *production* while at the same time promoting appropriate *demographic* policies. This ensures that both groups of activities become part of the agenda.

More specifically, in the two Conventions the transfers of technology and the provision of new and additional resources are promised in return for the fulfilment of commitments by developing countries. In the Biological Diversity Convention access to genetic material in linked to access to biotechnology by the country providing the resource. This linkage, however is inadequately dealt with in the Convention.

Conclusions

The international community can expect to see much negotiation and policy (both international and domestic) oriented activity that follows up on the areas implicated by Rio. One of the more obvious of these is that of negotiations for the development of protocols or other arrangements that will define clearly and put into practice the actual instruments that will make the actual functioning of the conventions possible. These include, amongst others, areas such as equity determinations, emissions standards, the definition of new and agreed incremental costs, technology transfer and intellectual property rights and issues of liability and compensation.

A clear picture of the cumulative impact of the UNCED process will probably take years to come to light. The mechanisms that Rio has attempted to put in place are complex and are related to many different areas of international relations. The functioning of the global economy, lifestyles of people all over the world; the very process of development itself could conceivably see significant changes, even perhaps before the end of the decade. For this to happen, however, it is necessary that governments demonstrate a will to deal cooperatively with the issues involved.

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The framework convention on climate change: some underlying economic issues

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Anand Prakash

".....one unifying characteristic of environmental resources is their regenerative capacity, a capacity which can be destroyed if they are exploited unwittingly."

(P. Dasgupta)

After two years of intense debate and negotiation, a number of countries have signed the United Nations Framework Convention on Climate Change at Rio de Janeiro in June, 1992. The Convention aims at stabilising the concentrations of all Greenhouse Gases (GHGs) so as to reduce a major threat to sustainable development i.e., dangerous anthropogenic interference with the Earth's climate system.

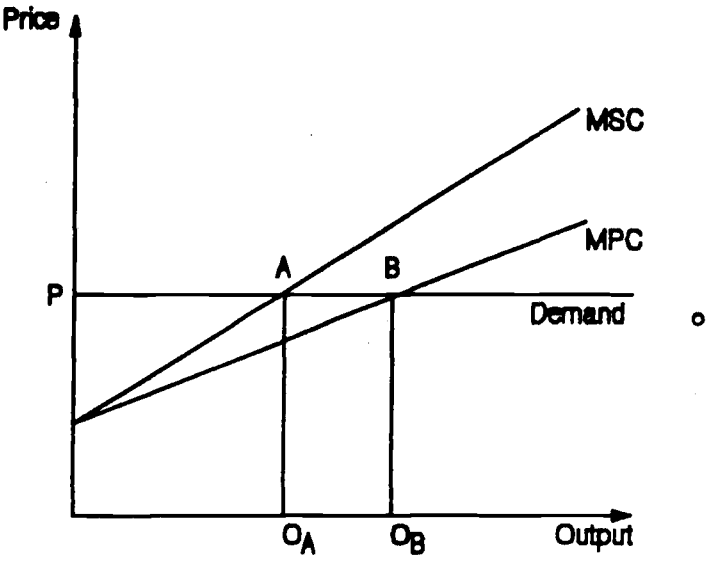
Several important economic issues relating to the global environment have come to fore in the Convention. This paper attempts to highlight and examine some of these issues from a developing country perspective. First, we look at the economic rationale for this Convention. This is followed by an analysis of technology transfer, macro-economic implications and international trade in the light of the Convention. The concluding section discusses some implications for future protocols to the Convention.

Externalities, free rides and market failure

Consider a firm that faces a perfectly elastic demand curve for its output.[25]

25. A perfectly elastic demand curve implies that the plant faces infinite demand at the given market price. In other words, the plant is too small to influence this price and can sell any amount of its output.

Also assume rising private marginal costs (MPC).[26] This implies that the total cost of producing an additional unit of output increases more than proportionately with every unit produced, as illustrated in the following figure.



At equilibrium, the firm maximises profits by producing output O_A at which its marginal cost of production equals the price. This, however, is a narrow treatment of costs. Suppose CO_2 is emitted during the production process as a by-product. Then, in addition to the private costs, the external costs of these emissions (in an extreme case, climate change) also need to be included in determining the marginal social cost which is the true cost to society. In other words,

Marginal Social Cost = Marginal Private Cost + Marginal External Cost

The marginal social cost (MSC) to produce a given level of output will always exceed the corresponding marginal private cost as long as the marginal external cost of production at that level of output is greater than zero. Hence, the optimum (maximum net benefit) level of output for society is less than that produced by the plant. In this case it is O_B

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26. Private costs comprise the costs of land, labour, capital, materials etc.

where the MSC equals price. Consequently, the plant produces an excess output of (O_A - O_B).

Another familiar example is that of deforestation in Brazil. The private cost of deforestation - at least as far as the problem of GHGs emissions is concerned - is less than the associated global cost. Hence, while a policy of deforestation may make "economic" sense for Brazil, it is inefficient from the point of view of the rest of the world.

The phenomenon of MSC exceeding MPC is characteristic of exploitation of "common resources", including the Earth's atmosphere. No country bears the full brunt of its polluting activities or enjoys the full benefits of environmentally friendly measures. Hence, there is a tendency to "free ride". This tendency is exacerbated by the non-excludable nature of the atmosphere. Thus, in the presence of externalities and non-excludability, the market mechanism fails to ensure an optimum allocation of resources.

The crux of the problem is that agents (firms, countries, etc.) do not face the social costs of their actions. Free riding is their strategic response which leads to market failure. It is here that governments have a role. Through environmental policies governments can ensure that polluters bear the cost they would shift onto the consumers. Likewise, without a world government, no existing institution can compel international polluters to pay [The Economist, May 30, 1992]. In a situation where unilateral action would be grossly inadequate, an international agreement is, ideally speaking, a (peaceful) way to make countries participate in containing anthropogenic climate change, without having some countries free ride on the efforts of others. The recognition of the need (and advantages) of global action to contain the present rate of GHGs emissions was the starting point for the Rio Convention.

Technology transfer

OECD estimates suggest that by the middle of the next century, stabilisation of CO_2 emissions by its member countries at current levels would reduce world output of CO_2 by 11% from the level it would otherwise have reached. This reduction could, however, be largely negated if the

developing countries, in their pursuit of development, spew more GHGs into the atmosphere. On some estimates, the CO_2 output of China would alone exceed that of the entire OECD.[27]

In recent years there has been a movement towards the development of environmentally friendly technologies (especially in Japan and Germany). These are technologies that use the earth's resources and its capacity to absorb waste as frugally as possible [The Economist, May 30, 1992]. However, due to the lack of purchasing power of the developing countries, institutional and other constraints, the access of these technologies to the developing countries has been limited. This limited access of to benign technology can hinder global efforts to stabilize anthropogenic emissions of GHGs.

This is where the role of policy measures to facilitate technology transfer comes in. Technology transfer is defined as the process by which technology, knowledge and/or information developed in an organization, in a given area, or for a particular purpose, is applied and utilised in a different setting or context [Bell, 1990]. It may take the form of a license for the use and revelation of a given technology for a specified term in exchange for royalty, and subject to other conditions (eg. restrictions on further transfer, R&D, exports, etc).

If developing countries have access to environmentally sound technologies early in their development process, the potential damage to the environment as a by-product of development can be mitigated. Recognising this point the Convention makes the following provision:

> "The developed country Parties ..... shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of environmentally sound technologies and know how to other parties, particularly developing country parties, to enable them to implement the provisions of the convention." [Article 4(5)]

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27. The Economist, May 30, 1992.

We analyse technology transfer in three categories:

A. Getting developed countries to share their technical know-how.

Technology can be crucial in gaining international competitiveness. Also, strong IPR regimes, (as portended by the draft Dunkel text[28]) yield significant economic rents to their holders, mainly agents in developed countries, which may be captured through exports of goods embodying the technology, no less than through royalty payments involved in the transfer of the technology in question. It may not, therefore, be in their interest to transfer state-of-the-art technology to others.[29] Instead, the temptation would be to transfer previous generation technology, which could, of course, be superior to that being used in the recipient country. This temptation will be further compounded by the presence of asymmetric information in favour of the developed country parties. Specifically, two factors could be at play:

- Moral hazard -- Moral hazard may be defined as actions of economic agents in maximising their own utility to the detriment of others in situations where they do not bear the full consequences or, equivalently, do not enjoy the full benefits of their actions due to uncertainty and incomplete or restricted contracts which prevent the assignment of full damages (benefits) to the agent responsible [Kotowitz in Palgrave: 1990]. Developed country agents have full information about the technology they are supplying, while those in the developing countries cannot observe this costlessly. This enables the former to increase their profits by supplying technology of a previous generation to the detriment of the latter.

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28. The draft Dunkel text is the draft presented at the Uruguay Round of the GATT negotiations by the Secretary General, Arthur Dunkel.

29. In fact, 99% of the 3.5 million patents are taken in developed countries and only 10% are worked in developing countries [Sengupta: 1991].

- Adverse selection -- Since developing country agents do not have complete information, they form their expectations by observing the range of quality of technology supplied in the market. They attach probabilities to getting different qualities of technology. Using these probabilities they determine the expected value of the technology being offered. The price they are willing to pay will lie between that of the most and least advanced technology being offered. At this price the developed country agents will not find it profitable to sell the advanced technology as the price the developing country agents offer will be less than what they expect. The iteration of the above phenomenon will result (in the extreme case) in only previous generation technology being offered in the market.

The implication is that from both the supply and the demand side, the market tends to move away from the state-of-the-art. While this may be relatively inefficient from the point of view of minimising GHGs emissions (since the potency of the continuously changing state-of-the-art to contain such emissions may exceed that of the second best), it may be optimal in the context of maximising global welfare. This is because in some cases, the developing countries themselves might prefer a second best technology to the state-of-the-art, since the former may be more appropriate for their economies. (see next section for further details on this argument).

Technology transfer is multi-dimensional. It can be categorized into three broad areas:

- actual level of know-how transferred - this spans the transfer of intellectual capital (blue-prints), physical capital, and final products
- the property rights over the technology transferred
- the nature of compensation (licence fees, side commodity deals, etc.) involved in the transfer

The Convention is silent about depth of technology transfer. This ambiguity leaves considerable room for the developed country agents to

manoeuvre the interpretation to maximise their gain at the expense of the developing country agents. The result could again be either the transfer of outdated technology or transfer in a very narrow framework. For example, such transfers may comprise only exports of the commodity embodying the technology, rather than the blue-prints or the physical capital needed to produce that commodity. This would leave the recipient country with no feasible option other than a continuous import of the commodity in question. Obviously, this involves significant opportunity costs for the recipient due to the continuous outflow of foreign exchange. Furthermore, the developed countries could also step up pressure on developing countries to change their existing IPR regimes if any transfer is to go through.

B. Suiting this know-how to the economic and social systems of the developing countries.

The advent of the debate on Global Warming has brought forward many persuasive arguments for switching to "clean" coal technologies such as the IGCC (Integrated Gas Combined Cycle). India set up a couple of pilot plants by importing gasifiers from Germany and USA. However, in field conditions in India it is found that the efficiency of the gasifiers was much less than that achieved in Germany/USA. This is because the gasifiers being used were developed for high quality coal whereas, Indian coal has a very high percentage of ash, clay and other extraneous matter.

The above example shows that the characteristics of technology are determined largely by the nature of economies for which they are designed. The most significant determinants are:[30]

- levels of income in the economy
- resource availability and the relative factor costs
- nature of the technology in use in the society
- system of organization of production in the society for which the technology is designed

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30. as identified by Stewart in Meier, 1989.

Therefore, the characteristics required of any (new) technology differ sharply between developed and developing countries. Appropriate technology is that which minimises economic costs given the resource base and other socio-economic conditions prevailing in the country. Thus, the state-of-the-art technology from developed countries may be inappropriate for developing countries and could lead to inefficiencies in these economies. It could, for example, lead to relatively abundant resources like labour being underutilized. It is precisely for this reason that developing countries may prefer a previous generation technology to the state-of-the-art.

This aspect has not been explicitly dealt with in the Convention. Perhaps a clearer elucidation of "agreed full incremental costs" that provides for the costs of adapting technologies to recipient economies is required to cover this aspect of technology transfer.

Another possible way around is joint research and development (R&D). Since the developing countries constitute a large part of the market for environmentally sound technology, leaders in such technology could start flagship R&D projects on a large scale in these countries catering specifically to their needs. The Convention says:

> " ..... developed country parties shall support the development and enhancement of endogenous capacities and technologies of developing country parties". [Art 4(5)]

However, joint R&D may not be in the interest of developed country agents as it could jeopardize their present monopoly over such technology. Therefore, a mutually satisfactory way to share IPRs will need to be devised, so as to provide sufficient incentives for such undertakings.

C. Overcoming resistance to technology change in developing countries.

Resistance to technical change exists mainly for two reasons. Firstly, there are infrastructural requirements associated with certain types of technologies. For example, setting up electronic telephone exchanges

requires that equipment be kept in air conditioned rooms. The absence of this facility in developing countries (due to erratic or non-existent power supply) discourages the establishment of electronic exchanges in rural areas. Secondly, a sizable portion of the population in most developing countries tread the thin line between subsistence incomes and starvation. This makes them highly risk averse and unwilling to use new techniques.

The significance of these factors lies in the fact the developing countries cannot thrust acceptance of new technologies on their people without substantial political and economic costs. In reality, using new, environmentally sound technologies could be painful. Therefore, unless sufficient measures are taken to provide

- insurance against the users lot being worse off than what it was before using the new technology
- education about the advantages of using the new technologies,

the proposed technology transfer could be ineffective. Once more, an appropriate definition of "agreed full incremental costs" which covers such implicit costs could be used to provide the resources which may help overcome this resistance.

The framework convention and the macro economy

Since the Climate Change Convention is aimed at stabilising GHGs emissions at a "sustainable" level, benefits (in the form of adaptation costs foregone) will accrue to all generations of humankind. However, achieving this inter-generational equity objective could impose considerable costs on the present generations.

The Convention implicitly recognises the historical responsibility of developed countries for the current levels of anthropogenic emissions of GHGs. It envisages a transfer of technology and financial resources from developed to developing countries, either in the form of grants or loans on concessional terms. The need for global action and the realization that the developing countries will not agree to take preventive measures if

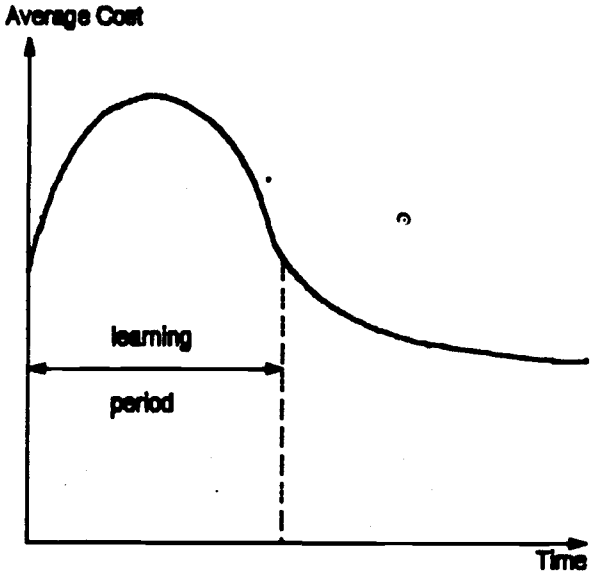
they interfere with their development process, together imply that mitigating climate change is a process of give and take.

Currently developed countries have a monopoly over environmentally friendly technologies. By transferring these to the developing countries they are effectively expanding the market for these technologies. A large part of the resources will flow back to the donor country in the form of demand for the goods produced by its firms and royalty earnings. The economic rent earned by any firm that enters a new market for such a technology will provide the wherewithal for further risk-bearing and innovation. Thus the firm will be able to gain a competitive advantage over the others in the industry. In a nut shell then, the aim is to gain a head-start in the future. Developed countries, therefore, stand to gain economic (and political) advantage in the domestic and international economy.

On the other hand, developing countries are aware of the importance of green lobbies in developed countries. They may thus see this as an opportunity to gain access to state-of-the-art technology. It is generally believed that though developing countries are labour abundant they are severely constrained by the availability of investable capital. The Convention may therefore be seen as a means for mobilising external resources to be used by the developing countries in their overall development effort. Thus it may be argued that the influx of capital under the aegis of the Convention will supplement scarce domestic resources of the developing countries and therefore push/pull them out of their current stagnation. While this may be theoretically correct, in reality it is rather simplistic. One must examine the macro-economic effects of the likely resource transfer given the socio-economic conditions prevailing in developing countries.

Picture a typical developing economy. It is characterised by the presence of a large agrarian sector, a high population pressure on resources, high levels of unemployment, high rates of inflation, declining productivity, sticky interest rates, apart from a huge external debt and low levels of social indicators (such as per capita income, literacy rates, etc.).

New technologies that enter the economy are typically designed in developed countries. They are likely to have a long "learning period" while they adapt to the economic conditions prevailing in the recipient developing economy. During this period the cost of production in the industries receiving these technologies will rise as shown in the figure below.



This figure shows the time profile of the average (social) cost curve of a firm that receives a new technology. Initially, the average cost to produce a given level of output will rise. However once the technology is endogenised the cost begins to fall and finally levels off.

In so far as a large part of the environmentally friendly technologies are likely to be concentrated in the energy and other industries with significant forward linkages, this higher cost will be transmitted throughout the economy.

At the same time, in each subsequent period there is an additional demand for capital -- partly to finance the continuing capital formation and partly to consolidate the market (i.e., strengthen the demand) for the commodity embodying the new technology. This is more so in the case of

environmentally benign technologies in developing countries, where a market for them may not exist at all since the global environment is not a major consideration in these countries. Therefore, for the resource transfer envisaged under the Convention to be effective, it is required that costs incurred to undertake such measures are also covered. The reason for this is that the developing countries are unlikely/unwilling to raise these resources domestically given their generally stagnating economies and the political unacceptability of increased taxation. However, there seems to be nothing in the Convention that ensures such a broad resource flow. On the contrary, this has been left open to debate and negotiation. Given the prevailing international power structure in the world today, it seems unlikely that such a broad flow will emerge. The only option left open to the developing countries will be to increase money supply -- either by printing more money or by obtaining additional funds internationally from outside the Convention.

To the extent that the transfer of resources to the developing countries will be in the form of aid (albeit on concessional terms), as against outright grants, there will be additional costs incurred by the developing countries. This is because past experience has shown that the bulk of aid is "tied". This tends to distort the pattern of investment towards those projects that have a large import component rather than projects/programmes which are primarily dependant on local resources, thus imposing opportunity costs on the recipient country.[31] Even if aid is not tied, there is scope for cartelisation in the supply of benign technologies, leading to "reverse" transfers of economic profits from the developing to developed countries. But, perhaps the greatest cost to the recipient country, in our case a developing country, accrues when it has to furnish interest and amortization payments. Given the stagnation and low/declining productivity in the developing countries, additional nominal

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31. To the extent that some of the resources under the Convention may be transferred through bilateral arrangements, aid may be tied by source also. This too has obvious opportunity costs for the recipient country which might be able to obtain the similar technology on much easier terms from another source.

flows need to be generated to finance these payments. The result is a further impetus to the on-going inflation. Moreover, to the extent that the developing countries may have to borrow in the international loan market to make the above payments they will be pushed further into the aid-debt spiral.

There are also other indirect costs associated with increased environmental aid. Firstly, since such aid is to be "new and additional" i.e., in addition to the other development aid that the developing countries receive, it implies worsening of the debt-service ratios for the developing countries. The result will be a decline in their credit worthiness in the international aid/loan market. The implications of this could be far reaching as it might mean less and/or more stringent aid to the developing countries thereby jeopardising their overall development programme. Secondly, all interest and amortization payments have to be made in an internationally acceptable currency. Consequently, this places a strain on the foreign exchange reserves and (in a regime of flexible exchange rates), exchange rates of the debtor country. The resulting deterioration in the terms of trade may lead to an increasingly adverse balance of trade. This is because developing countries exports typically have low price elasticities and the relative decline in the price of exports will not be offset by a more than proportionate increase in the quantity exported. Quite apart from this, in so far as the (positive) gap between the domestic inflation rate and the world average is increased, there is a loss of competitiveness in the international market for exports from developing countries.

The Rio Declaration invokes the Polluter Pays Principle for meeting the costs incurred in undertaking abatement measures. Since the Declaration contains the guiding principles for all other documents emanating from the UNCED process, it is applicable to the Climate Change Convention. To this extent, the resource transfers could be interpreted as "polluter dues". This could imply that a significant portion of these transfers could be made in the form of grants or at least on more concessional aid. Furthermore, the "tied" component of the aid could also

be lessened. These changes could appreciably alleviate some of the costs incurred by the developing countries (as discussed above).

Thus, while it may be possible to establish an international Climate Fund it is essential to disburse these funds in a manner that assists the developing countries in limiting GHGs emissions without exacerbating existing international and domestic inequalities. What is important is the efficacy with which the resources transferred under the Convention are integrated into the overall development effort of the developing countries. The governments of these countries will have to mobilise their own resources and implement complementary programs that enhance the productivity of their economies so as to prevent environmental aid from being detrimental and to realise the full potential of the incoming technology and financial resources.

In recent years many developing countries have embarked on programmes of structural adjustment of their economies. It will be crucial how these countries can integrate these environmental considerations into their policies or national strategies. The structural adjustment can be complimented by these new technologies and resources making the transition a smoother process.

Trade and environment: A case for protectionism?

There has been increased awareness in recent years about the need for a cleaner environment, and a growing realisation that using products produced by environmentally friendly production processes is an important way of achieving this. This has created an international "green market", in both products and technology. Trade can help exploit this market. Countries such as Germany and Japan have come to realise that an "early first" comparative advantage can be gained in the not so distant future by adopting more stringent environmental standards now, as they feel the world will follow suit soon. Besides, there is political mileage to be gained by being world leaders in environmental issues as there is reason to believe that other countries will not let the green market/constituency go uncompeted for.

However, trade also creates disincentives for the protection of the environment. Most environmentally benign technologies have high capital costs (though they may have positive net present values). Therefore, in the short run this results in a loss of competitiveness for their users in an international scenario where not everyone is using such technologies. In the same spirit, relatively lax environmental standards in a country provide an "ecological subsidy" to its industries making them more competitive than those in countries with more stringent standards. This might result in the shift of production to these "dirty" countries to the detriment of the environment.

The protection of the environment has thus provided a rationale for tariff barriers or imposing unilateral trade sanctions. By keeping out commodities that do not meet domestic environmental standards countries can provide protection to their own industry against potential competition.

Conversely, when sanctions are imposed for other economic reasons, such as the protection of inefficient domestic industries, these can work against the environment. For example, a protected agricultural sector based on the intensive use of chemical fertilisers prevents entry of like commodities from other countries with lower fertiliser intensities. The by-product of this protection is a higher emission of GHGs by the protecting country, (and also an increase in other local pollution impacts).

Also, there may differences in the perception of the risk posed by a polluted (global) environment. This divergence in perceptions, especially marked between developed and developing countries, is reflected in a lower willingness to pay for its cleaning up and therefore, in a lower social cost in the latter countries. Thus, even if countries have similar environmental standards, these may be met at markedly different costs. This difference in costs could be perceived as another ecological subsidy for the industries in the developing countries. This provides an incentive to the developed countries to impose countervailing measures.

Recognising the potential for protectionism the Climate Change Convention has made the following provision:

> " The Parties should cooperate to promote a supportive and open international economic system.....Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade." [Article 3(5)]

It is interesting that the italicised phrase also appears in the General Agreement on Tariffs and Trade (GATT) under article XX.[32] Thus, the inclusion of the phrase could be an effort to harmonise/reconcile the Convention and GATT. In this, the Convention is one of the few international agreements on the environment that prohibits the use of trade barriers. There are, however, some problems might persist.

Most of the cases relating to the abuse of the environment that have been struck down by a GATT panel have been related to either local resources lying within a country's national jurisdiction and/or concern environmental resources not protected an international agreement. In the case of global climate change we are faced with a diametrically opposite situation. The issue at hand is one of transboundary pollution of a protected global common. Thus if a future protocol to the Framework Convention were to allow the use of unilateral trade sanctions or other barriers as an explicit (rather than a disguised/unjustifiable) enforcement

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32. Article XX relates to general exceptions. In particular, it provides for the following:

> *Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries ....., or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures:.....*
>
> > *(b) Necessary to protect human, animal or plant life or health;*
> > *(g) Relating to conservation exhaustible natural resources, if such measures are made effective in conjunction with restrictions on domestic production or consumption;.....*[GATT: 1986]

mechanism against violations of obligations, these might be upheld by GATT, as an exception to the other GATT requirements that all members treat imports and domestically produced commodities in a like manner, as also all trading partners. Failing this, a GATT waiver can be requested, especially if the signatories to the proposed protocol are mostly GATT members.[33] In fact, in the context of climate change, the use of waivers would ensure that the trade measures are focused on the issue at hand, are transparent and are multilaterally negotiated [GATT: 1992].

This brings us to the question of whether the environment can be protected without resorting to outright protectionism. Alteration of consumer preferences in favour of environmentally friendly products, in other words, strengthening the green market, is a possible way. Suppose country X has achieved such an alteration through public awareness campaigns. Also, the domestic policy of this country is to label all commodities, whether imported or produced domestically, that meet certain minimum environmental standards. (This would not be GATT-illegal as imports from any source and domestic production are treated identically). In this case, even though a trading partner using environmentally less efficient production processes is allowed to enter the domestic market of X, it likely to suffer a loss in market share in this country. This is because, the ceteris paribus, the demand for unfriendly products has reduced. Here, the alteration of consumer preferences in favour of a differentiated product has created market incentives for protecting the environment without being GATT illegal.

Implications for future protocols

For an agreement to be successfully implemented, it is important for it to be self enforcing. The problems faced in the implementation of international agreements (such as the Climate Change Convention) are typified

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33. To obtain a waiver under GATT a two thirds majority of the votes cast is required, with the additional requirement that these two thirds comprise more than half of the contracting parties.

by the Prisoners' Dilemma. If all parties to the agreement abide by their commitments they maximise their joint payoffs. However, individually, their interests are best served by a strategy of violation. Therefore, the dominant strategy for each party to the Convention would be to continue emissions of GHGs above the agreed levels by not signing future protocols to the Convention.

An ideal way (in a Game Theoretic framework) to implement any future protocol to the Convention would be to alter the payoffs in the "emissions game" so that stabilising emissions at the agreed levels becomes the dominant strategy. This alteration could, however, involve the use of harsh measures such as trade sanctions, reduced financial assistance, etc, which may discourage many nations from signing on. In international agreements, therefore, it sometimes pays to leave the protocols to such Conventions somewhat vague so as to get more nations on board. On the other hand, there might exist positive measures that change the pay-off matrix in a manner that makes every one better off by signing the agreement. Tradeable permits may be one such instrument. Countries that exceed their allotted levels could purchase the right to emit from those that have a surplus of emission rights. This would provide an incentive to both parties. The excess emitters could continue their emissions above the allowable level while countries with lower emissions can generate resources through this mechanism. At the same time, the increasing imbalance between the demand and supply of these permits that is likely to occur as an growing number of (developing) countries increase their emissions in their pursuit of development will raise their price, which would create incentives for increasing GHGs efficiency.

That protocols to the Climate Change Convention will be incomplete contracts should be kept in mind. The writing of a complete contract will be particularly difficult in this case due to the following reasons:

- protocols would involve complex transactions and long time periods. This will make writing detailed contingent contracts very costly.

- there is a high degree of scientific uncertainty in the Climate Change debate. This is largely due the large number and the complex nature of possible eventualities. Hence, contracting for each possible outcome is a virtual impossibility.

The implementation of any incomplete contract might be hampered by the non-existence of a strict enforcement mechanism. This absence does not necessarily imply that the contract is doomed to failure. There exist forces outside the protocol (such as public opinion, international political pressure, etc.) that can ensure its effective implementation.

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The implications of agenda 21 - an overview

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Introduction

The UN Conference on Environment and Development (UNCED) held in Rio de Janeiro from 3-14 June 1992 was an important milestone in international cooperation to tackle environment and development issues. While the 1972 Stockholm Conference on the Human Environment initiated global awareness about environmental issues, UNCED affirmed the importance of the twin issues of environment and development being addressed in a balanced and comprehensive manner. As a result of UNCED, the protection of the environment has been accepted as being inseparably linked to the promotion of development and has emerged as one of the few areas where a meaningful North-South economic dialogue is in progress.

Perhaps the most important operational output of UNCED was the agreement reached on Agenda 21. While Agenda 21 is not legally binding, its endorsement by more than 180 countries, of which over a hundred were represented at Rio at the level of Heads of State/Government, clearly reflects the importance assigned to it by the global community and the high level political commitment to its contents.

Preamble: political aspects

The overall focus and sense of direction to Agenda 21 is provided by its carefully negotiated Preamble, which constitutes the first of its 40

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chapters. The Preamble specifies that the integration of environment and development concerns and the devotion of greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. It emphasises that nations acting alone cannot achieve this objective. They can, however, do so through a global partnership which builds upon the premises of UNGA Resolution 44/228 of 22 December 1989 and the acceptance of the need for a balanced and integrated approach to environment and development. While stressing that the successful implementation of Agenda 21 is "first and foremost" the responsibility of governments, the Preamble also states unambiguously that international cooperation should "support and supplement" rather than seek to supplant national efforts.

To achieve the development and environment objectives of Agenda 21, the developing countries will require a substantial flow of "new and additional" financial resources to cover the incremental costs of their actions to deal with global environmental problems and to accelerate sustainable development. This crucially important reference for developing countries has been deliberately included in the Preamble. Following intense negotiations, a secondary reference has consciously been given to the economies in transition, with the Preamble acknowledging in a subsequent paragraph that "special attention" should be given to their particular circumstances.

The entire text of Agenda 21 was negotiated during the UNCED process and it thus reflects the agreements reached amongst participating States. The Preamble, however, makes clear that Agenda 21 is a "dynamic" programme which could "evolve over time" in the light of changing needs and circumstances. Moreover, the Preamble recognises that Agenda 21 will be carried out by the various actors "according to the different situations, capacities and priorities of countries and regions". These inclusions, which provide the necessary flexibility, also allow for a subsequent review of Agenda 21, and are important since Agenda 21 addresses not only the pressing problems of the day but also aims at preparing the world for the challenges of the next century.

It is of interest that the term "sustainable development", though widely used, has not been defined either in Agenda 21 or in any of the other texts emerging from UNCED. Nor was any serious attempt made during the negotiations to work out such a definition. The meaning of "sustainable development" could, however, be distilled in many instances from the context in which the term is used as the link between environment and development - the twin concerns of UNCED, the essence of the concept of sustainable development, however, lies in the process of improvement of the quality of human life, doing so within the carryhing capacity of supporting ecosystems.

Preamble: economic aspects

The Preamble demarcates sustainable development concerns. These include intra- and international equity, "poverty, hunger, ill-health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being. The ecosystem is accordingly, viewed in strictly anthropocentric terms, a position also unambiguously articulated in the Rio Declaration on Environment & Development. While fulfilment of basic human needs are considered to be at the core of sustainable development, the focus on equity is limited by an assertion of expectation of strict Pareto improvements ("improved living standards for all") through "integration of environment and development concerns". Further, since flows of "new and additional financial resources" are aimed solely at covering "incremental costs" that may be faced by DCs for actions to be taken by them, the equity content of the document does not encompass any principle of sharing global resources, internationally, or intergenerationally. While the Preamble does not mention the "polluter pays" principle, which could be urged simply as a means of efficiency, without invoking equity considerations, later sections of the document speak of employing this principle in specific contexts.

Governments are identified as the key agencies for implementation, by way of "national strategies, plans, policies and processes". Implicit in this assignment is an acknowledgement that environmental protection and its harmonization with development cannot be left to

unregulated private markets. At the same time, the reference to broadest public participation and active NGO involvement, points to the need for the involvement of all in order to make Agenda 21 a success.

For ease of consideration, Chapters of Agenda 21 subsequent to the Preamble could be broadly classified into four parts, viz., Part-I addressing "Social and Economic Dimensions" (Chapters 2-8), Part-II concerning "Conservation and Management of Resources for Development" (Chapters 9-12), Part-III regarding "Strenghtening the Role of Major Groups" (Chapters 23-32) and Part-IV on "Means of Implementation" (Chapters 33-40). The rest of this paper is also structured on these lines.

Social and economic dimensions

Political aspects

This part of Agenda 21 focuses on those areas of the environment-development debate which are more directly linked with developmental issues, in particular their economic and social dimensions. The importance of a supportive international climate for achieving environment and development goals has been emphasized, and for this purpose sustainable development is to be promoted through trade liberalisation, making trade and the environment mutually supportive, providing adequate financial resources to developing countries for dealing with their international debt, and encouraging appropriate macro-economic policies. An open, equitable, secure, non-discriminatory and predictable multilateral trading system in which the commodity exports of the developing countries can find markets at fair prices, and without the imposition of unjustified trade barriers, has been viewed as an importantly requisite for sustainable development.

The Chapter on poverty recognizes poverty as a complex, multidimensional problem to tackle which country specific programmes would be crucial. It is accepted that the eradication of poverty and hunger, greater equity in income distribution, and the development of human resources are the major challenges on which all countries mustcooperate and share responsibility. It is particularly noteworthy that Agenda 21 acknowledges

as a matter of grave concern that, while poverty results in certain kinds of environemental stress, the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrialized countries. Agenda 21 further recognizes the need to develop strategies to mitigate both the adverse impact on the environment of human activities as well as the adverse implications of environmental change on human populations. Expectedly, protection and promotion of human health has been looked at as part of an overall strategy for achieving the WHO target of a minimum standard of health for all by the year 2000.

The Chapter on promoting the development of sustainable human settlements is of particular importance since over one billion people do not have access to safe and healthy shelter. However, the provision of adequate shelter and improvement of urban infrastructure and municipal services in developing countries would require generation of considerable domestic resources over and above international cooperative efforts and aid flows. The identification of domestic finances to make the proposed action programme a success has been correctly left to each country. The reshaping of the planning process is another area where domestic changes in many countries may be required if Agenda 21 is to succeed. The main thrust of the Chapter on integrating environment and development is to urge nations and industrial enterprises to integrate at the outset environmental protection, degradation and restoration costs into decision making.

Economic implications

In contrast to the acknowledged need for Governmental intervention for SD in national policy contexts, trade liberalization is asserted to be quite generally conducive to environmental conservation, in addition to development goals. Further, the harmonization of national policies with a (supportive) international economic environment is asserted to be essential.

A strong result from economic theory is that under fairly tight assumptions, free trade is Pareto efficient, i.e., facilitates growth. One

key assumption involved in this result is that in the presence of environmental externalities, property rights are created and costlessly enforced over environmental resources, in addition to conventional valued resources. In other words that a norm of "internalization of all external effects" (a generalization of "polluter pays") is embodied in a regulatory framework at the level appropriate to the externality impacts, i.e., local, national, regional, or global. Some multilateral regimes, e.g., the Montreal Protocol, the Biodiversity Convention, and a few others, attempt to do this. At the national level, the instances are more numerous, e.g., the U.S. Clean Air Act, etc.

Clearly, efficiency gains from trade would be increasingly realized as environmental regulation at appropriate levels becomes more comprehensive.

The document also implies that making "trade and environment mutually supportive" is an independent condition for achieving environment and development goals. In fact this condition is completely contained in the first, i.e., requiring the assignment of property rights in the environment. Of course, in the absence of fully liberalized trade with environmental property rights, there may exist scope for employing *trade restrictions* for environmental *protection*, although in this case there may not be any efficiency improvement over liberalization without environmental property rights.

Developing Countries (DCs) are concerned that environmental protection should not be a pretext for instituting Non-Tariff Barriers (NTBs) on trade. One rider in the document is that account should be taken of the fact that "environmental standards valid for developed countries (ICs) may have unwarranted social and economic costs in DCs". Efficiency requires that standards must be related both to valuations of environmental damage by the impacted publics, as well as the costs of abatement. Two kinds of standards may be involved. Applied to processes, efficiency considerations would clearly debar trade restrictions premised on uniform, local or national environmental impacts. For processes whose environmental impacts are global, unilateral advances over global standards that may be adopted could be justified in terms of additional

national objectives. However, if trade liberalization is an independent global objective, i.e., in addition to global environmental protection, a conflict may arise over these further national objectives, and the global imperative of trade liberalization. If efficiency is a strongly pressed global policy premise, the conflict must be resolved in favour of trade liberalization.

The possibility also exists that countries may attempt to subsidize environmentally benign technologies in export sectors. One issue that may arise is that other countries participating in multilateral trading regimes (GATT) may perceive such subsidies as intended to confer a competitive (financial) advantage to the sector, and thus violative of the multilateral regime. How exactly such a dispute would be resolved by the appropriate resolution mechanism is unclear. Another aspect is that a strong result from the economic theory of environmental regulation suggests that, under fairly general assumptions, such subsidies may, by encouraging entry into the (subsidized) polluting industry, increase the overall level of environmental damage.

Environmental impacts of products (i.e., after manufacture and sale) would relate to their impacts in use and disposal. If these are all contained within national jurisdictions, efficiency considerations may be used to justify unilateral, but uniform standards related to just these impacts, without regard to country of origin provided there are no other discriminatory (i.e., across countries of orign) barriers, either tariffs or non-tariff. This would retain the competitive advantage of the most efficient suppliers.

Accelerating the diffusion of (at least) process technology is a clear means of reducing environmental impacts. This could impact IPRs regimes in which trade-offs between static and dynamic efficiency are captured in the tension between weaker and stronger IPRs protection. Faster diffusion with strong incentive provisions for knowledge creation in IPRs regimes would imply a greater committment of financial resources to pay for such technology transfers.

Liberalization of foreign investment, debt relief, and general macroeconomic stabilization are urged in the document as significant for

SD. The causal links between these and conventional GDP growth is well understood, but those with environmental protection require elaboration. Capital inflows and an outward orientation of national economies both facilitate and require greater technical efficiency in the use of natural resources, acknowledged by economists and policy makers to be an important attribute of SD. GDP growth itself, given appropriate policies, enables the adoption of environmental protection measures in national economies, since these may involve real resource costs. If such growth is also translated to removal of poverty, people could alter unsustainable lifestyles, for example based on exploitation of common property resources (CPRs), e.g., forests, grazing pasture land, and fisheries.

The subsection on poverty incorporates several paradigm shifts in the development literature that have occurred over the years, including by indirection that it has historical origins in national dominance, through acknowledgement of the "shared responsibility of all countries" for the problem. At the same time, the assertion of poverty being a complex multidimensional problem may refer to its links with social structures, as well as culture, that have been discussed in the literature.

Approaches to poverty imply repudiation of subsidy based approaches to increasing consumption, or of significant intra- or international redistribution of resources. The focus is on (political) empowerment of the poor, including disadvantaged groups (women, indigenous communities), and human capital formation, primarily through education and professional training. In addition, emphasis on access to (not ownership of) productive resources, and income equity, involve a clear rejection of "trickle down" growth. Indeed, a shift of emphasis from growth as the principal development criterion is manifest in requiring policies "to simultaneously address development, sustainable resource management, and poverty eradication." The currently believed strong causal linkages between poverty, women's status, population growth, women's access to health care, infant survival (breast feeding, clean water, and sanitation), are clearly embodied in the document.

Unsustainable patterns of production and consumption (in ICs) are asserted in the document to be the major cause of global environmental

degradation, aggravating poverty. Several themes have been articulated. These include redefinition of notions of growth to account for natural resources depletion, and of living standards which reflect SD concerns. Also, greater efficiency in production and altering consumption patterns, as well as of development in ICs, which have served as models of growth in many DCs. Policies to encourage these shifts include (largely) incentive based instruments to implicitly incorporate externality costs of resource use, dissemination of, increasing access to, and promoting R&D in environmentally friendly technologies, energy efficiency, use of new and renewable energy and natural resources, and assistance to DCs.

These recommendations, however, stop short of advocating major changes in ICs life styles, or advocating alternative growth paths in DCs. Incentive based instruments, which economists would tend to support unless market distortions were pervasive or administration costs were major, are not urged on efficiency considerations, but (apparently) in order that a decentralized decision process rather than fiats, accomplishes these objectives. A value judgement in favour of decentralization, also evident in the general emphasis in the document in empowerment of special groups and local communities, would be involved here. Efficiency considerations (broadly defined) are also implicit in amending concepts of GDP and redefining living standards.

Together with production and consumption, *world* population is asserted to stress the life-support systems of the earth, besides other critical resources. Once again a paradigm shift is evident. Earlier approaches to population increase, i.e., emphasis on technical means of reproductive choice, as well as material incentives for limiting family size have been eschewed. The document advocates, first, deeper research based understanding of population change and its links with technology, culture, natural resources, and life-support systems. Second, integration of population growth concerns in a wider environment and development perspective. For example, this would include urban management and local government issues in DCs.

This approach equates the issue of unsustainable production and consumption with that of population in terms of potential for environ-

mental degradation of a life threatening kind. In addition, the avowedly holistic approach to population, would rule out any near term or "Big-Bang" schemes for stabilization, and by implication, the world is committed to significant population increase in the medium term. The question of equitable entitlements to global resources given this committed increase, and the implications of such allocations for restraining present unsustainable production and consumption patterns, besides population growth itself, is not addressed.

Human health is viewed in the document as an instrument for "sound development", rather than as an independent attribute of SD. Health risks are acknowledged to result from environmental impacts of development, and also from lack of development. A responsibility for Governments in addressing health issues is evident. In fact, a stress on "doing with" rather than "doing for" could be interpreted as viewing health as a private good with some externality benefits, rather than as essentially a public good. This may have deep implications for designing systems of delivery of health care.

Proposals for promoting sustainable human settlements envisage a comprehensive approach to shelter, urban management, infrastructure, equity in land use, transportation, safety, and the construction industry. Clearly, but implicitly, much initiative would vest with national and local governments. What is missing? The urban settlements sector is extremely capital and skills intensive. The question of skills is addressed, that of resources is implicitly left to national governments. The latter aspect also involves the question of institutional structures within countries to tap domestic resources and operate infrastructure and utilities, besides mass transportation, efficiently. The question of such institution building in the urban settlements sector is a clearly a major challenge for sustainable development.

The principal field for capacity building remains policy making. Most developing countries are short of the critical human resources of entrepreneurial, managerial, and administrative capacity. Further, generations of policy makers in DCs have acquired the reflex of making policies by sector i.e., piecemeal, employing instruments which attempt

detailed case by case regulation by fiat, and which are accordingly intensive in the use of bureaucratic resources and information. Agenda 21 proposals regarding policy making for SD envisage a sharp reversal of these practices. In particular, the integration of planning in all relevant areas of environment and development is envisaged. Further, while the use of decentralized regulatory instruments, in particular those which work through market signals, as well as the removal of distortionary incentives, is recommended, there is also emphasis on a broader range of public participation. This latter aspect may be owing to the fact that in several areas of economic activity, market failures may occur on the demand side, including for example, environmental quality, and social and physical infrastructure, and accordingly, unregulated market approaches may be inefficient.

Conservation and management of resources for development:

Political aspects

Noteworthy in the chapter on protection of the atmosphere is the importance attached to reducing uncertainities in areas such as climate change and climate variability, air pollution and ozone depletion. The intention behind this focus is to improve the scientific basis for decision making. It is equally interesting that the chapter on protecting the atmosphere does not mention fossil fuels, covers all greenhouse gases, and limits commitments for corrective action to the agreements reached in the Framework Convention on Climate Change (1992). It is also of considerable significance that Agenda 21 identifies the importance of the growing reliance that would have to be placed on environmentally sound energy systems, particularly new and renewable sources of energy. The debate over whether environmentally "safe and sound" energy systems should be considered for promoting sustainable development or whether environmentally "sound" energy systems would suffice was a major contentious issue which only got resolved on the final day of UNCED. While a consensus was ultimately reached, a couple of delegations from oil producing States, insisted on placing on record their objections to what

they described as the promotion of the utilization of "unsafe and environmentally unsound technology and energy sources, such as nuclear energy".

Agenda 21 also visualizes an integrated approach to land resource use which would involve simultaneous consideration being given to environmental, social and economic issues. Similarly, the chapter on the "Conservation and Rational Use of Forests" emphasizes the importance of recognizing the social, economic and ecological values of forests and the need to incorporate such values into natiional accounting systems. The contents of this chapter are further buttressed by the adoption separately of a "Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests".

The problems posed by desertification and drought for a very large number of developing countries has been focussed upon in a separate chapter. Priority has been accorded to halting the spread of deserts by adopting preventive measures particularly for lands which are not yet degraded, or which are only slightly degraded. At UNCED agreement was, however, reached to elaborate an international convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa, and such a convention is to be finalised by June 1994.

Like the Convention on Biological Diversity (1992), the Agenda 21 chapter devoted to biodiversity recognises the sovereignty of States over their genetic resources, and its contents essentially parallel the matching provisions of the Biodiversity Convention. The chapter on environmentally sound management of biotechnology calls for the transfer of biotechnology to developing countries and the creation of the the necessary infrastructure as regards capacity building and human resource development in developing countries.

The chapter on the protection of the oceans recognises that the rights and obligations of States set out in the UN Convention on the Law of the Sea provides the international basis on which to pursue the protection and sustainable development of the marine and coastal

environment and its resources. It is specifically recognised that the implementation by the developing countries of the activities listed in the chapter would be commensurate with their individual technological and financial capacities and priorities in allocating resources for development needs, and would ultimately depend on the technology transfer and financial resources required and made available to them. An intergovernmental conference would be convened under UN auspices with a view to promoting the effective implementation of the provisions of UNCLOS on straddling fish stocks and highly migratory fish stocks. However, the work and the results of that conference would have to be fully consistent with the provisions of UNCLOS, in particular, those relating to the rights and obligations of coastal states and states fishing on the high seas. The chapter on protection of the quality and supply of freshwater resources is of particular interest to developing countries. As regards drinking water supply and sanitation, it bases proposed activities on the four guiding principles of the New Delhi Statement of 14 September 1990 which formulized the need to provide, on a sustainable basis, access to safe drinking water in sufficient quantities and proper sanitation for all, emphasising the "some for all rather than more for some" approach. Freshwater management is proposed to be holistic, and based on a balanced consideration of the needs of people and the environment.

The chapter on environmentally sound management of toxic chemicals includes a separate programme area on prevention of illegal international traffic in toxic and dangerous products and incorporates noteworthy references to the PIC procedure. It is noteworthy that the chapter on environmentally sound management of hazardous wastes includes as an overall target the requirement of ensuring that environmentally sound hazardous waste management options be pursued to the maximum extent possible within the country of origin ("self-sufficiency principle"). Governments are also required to ascertain that their military establishments conform to their nationally applicable environmental norms in the treatment and dsiposal of hazardous wastes. Of particular interest in the chapter on safe and environmentally sound management of radioactive wastes is the requirement that states not

promote or allow the storage or disposal of high level, intermediate level, and low level radioactive wastes near the marine environment unless scientific evidence, consistent with the applicable internationally agreed principles and guidelines, shows that such storage or disposal poses no unacceptable risk to people and the marine environment or does not interfere with other legitimate use of the sea.

Economic aspects

The impacts of anthropogenic activities on key resources: atmosphere, forests, land, oceans, freshwater, etc., are profoundly uncertain. A major thrust of proposals for resource management, accordingly, centre on reducing uncertainties through research.

A second focus of proposals on resource management is the development of capacities and capabilities for research on impacts, planning and policy making, and technological innovation and absorption.

A third area of emphasis is the empowerment of groups which would be adversely affected by degradation. The underlying belief is that public policies have major impacts on conservation of natural resources, and that by such empowerment, policy making could be influenced in the direction of sustainability. Since many of these potentially impacted groups, for example indigenous people, might also be identified as underprivileged, there is an apparent synergy between equity and sustainability concerns.

One major resource which is adversely impacted by economic activities is the atmosphere. This is because of its close links with energy supply and use. The atmosphere is the principal recipient of environmentally damaging discharges from the use of fossil fuels. The impacts may be at all levels: local, regional, global. In particular, the costs of global impacts, largely on climate, may be very high, but are uncertain over wide limits. Uncertainties are involved both in mapping the build-up of pollutants from specific energy use activities, as well as how they translate to adverse climatic and other externality impacts. Accordingly, the proposals on protection of the atmosphere focus on the production and use of energy.

Energy production and use is, of course, intricately linked to economic activity, and is a principal determinant of living standards and development. The tension between development and environmental protection, sought to be resolved in concepts of SD, is nowhere sharper than in the energy sectors.

Energy is a ubiquitous input in production, and in the long-run, a substitute for (or may be complemented by) other inputs: Land, labour, capital. It is also an important good in both private and public consumption, besides constituting a major revenue source through indirect taxes, royalties, and leases. Policies that impact energy supply and use, can thus, through inter- industry linkages, and changes in factors use, impact all sectors, besides incomes, savings, investment, and public and private consumption. Changes in international comparative and competitive advantage could also clearly occur, affecting patterns of trade. Any scheme for environmental protection focussing on the energy sectors will, therefore, have to address the potential wideranging impacts on the economy.

Agenda 21 proposals attempt a fairly comprehensive approach, recommending national planning to integrate energy, environment, and economic policy in a sustainable framework. The internalization of environmental costs through economic (incentive based) and regulatory (fiats) measures is also urged as a planning goal. Economists generally prefer incentive based instruments which, in effect, price the resource to the user, to fiats. The former under a set of assumptions will permit a given level of environmental quality to be reached at the least resource cost. Several incentive based instruments., e.g., pollution taxes, tradeable permits, may also be designed to raise significant revenues for funding SD measures, or meeting equity concerns. However, Agenda 21 does not urge the adoption of (economic) regulatory instruments in a multilateral framework, i.e., with States as the regulated agents.

One important set of policies which may have significant complementarities with economic efficiency goals is increased energy efficiency and conservation. The reduced use of primary energy, in particular fossil fuels, through increased energy efficiency will reduce polluting emissions

and discharges, and thus promote sustainability. Accordingly, the document also proposes the development and use of energy efficient technologies, setting goals for energy efficiency, and technology transfers to DCs. Of course, under the Climate Convention, the responsibilities of DCs for implementing national abatement strategies is conditional not only on the fact of such technology transfers, but also on the "(agreed) full incremental costs" ("agreed": under norms to be decided) being met by ICs. Questions relating to the appropriate depth of technology transfer would need to be addressed in future negotiations. Several energy sources are identified as "sustainable" and therefore meriting increased research. These include solar, wind, geothermal, hydropower, and biomass (including wood). All of these, of course, have a range of environmental impacts. On the other hand, nuclear power may, on balance, have lower environmental costs than these named sustainable energy sources. The listing of "sustainable" energy sources thus, does not appear to have been examined on the basis of economic (efficiency, equity, sustainability) criteria.

Land resources are also subject to stress from a diversity of economic activities. The objectives of land resource conservation measures are articulated as the allocation of land efficiently, i.e., maximization of sustainable net benefits, with the empowerment of potentially impacted groups a matter of additional emphasis. A focus on private property also reflects economists' belief that the common property nature of many land resources fosters their unsustainable use, leading to degradation. A review of the regulatory framework, including legislation, is urged for promoting sustainable land management, but also to restrict the transfer of arable land to other uses. This may conflict with efficiency, and represents an *a-priori* political determination that diversion of agricultural land to other uses is not desirable from the viewpoint.

Proposals for forestry conservation recognize the use of this resource in multiple economic uses, besides ecological, social and cultural uses. This reflects the belief that deforestation arises largely from the failure of existing institutions to internalize the value of externality benefits which are in the nature of non-excludable public goods, leading

agents to neglect societal costs of deforestation. However there are major difficulties in designing policy instruments to accomplish such internalization by decentralized agents, and the principal means of arresting deforestation remain direct Government regulation, and recognizing and enhancing the rights of traditional users of forest resources. There are large uncertainties in computing the value of external benefits of forests, and accordingly, their incorporation in national accounting systems may also present serious difficulties.

Some approaches to conservation in the document include promoting non-wood forest products, eco-tourism, and more efficient fuelwood harvesting and use. These may enhance the private benefits from forestry, and accordingly reduce deforestation rates.

Capacity building in the forest sector is a major focus of the proposals. This follows from recognition of the multi-disciplinary nature of forestry management, which is the key to effective Government regulation of the resource.

The priority in combating desertification is preventive measures on lands not yet (or only partly) degraded. This may reflect an assumption that the net benefits of investments in prevention are likely to be greater than in the case of reclamation. The possibility of serious contributions from indigenous knowledge to scientific research in these aspects is recognized. However, some traditional livelihoods may have become unsustainable due to drought and population increase, and these may be altered. The fact that cultural transitions may be involved is, however, not addressed. This accords with the omission of human culture as among the attributes of sustainable development.

Droughts may lead to disaster and refugee problems. While relief measures are proposed, the question of drought (disaster) arising as a result of external activities, meriting compensatory rather than paternalistic responses by the concerned entities, is not discussed.

Mountain ecosystems are a valuable component of global ecosystems. Approaches to conservation of the resource focus, first, on the fact that it is still inadequately researched, and second, on the development

of alternative activities at the village level which could be undertaken in sustainable ways.

Approaches to agriculture focus on removing policy distortions in many countries, as well as trade barriers. This may enable DCs in general to realize their competitive advantage in many agricultural commodities. There is, however, no specific mention of price stabilization. A framework for food security is recommended, including the transfer of storage and distribution technologies. Other interesting proposals relate to ensuring access to agricultural resources to underprivileged groups, extending financial networks (which may require increased research and experimentation in credit delivery methods to underprivileged groups), sharing benefits of R&D in plant breeding and seed production, integrated pest management, and soil fertility management. In particular, an energy transition in rural areas is necessary: This may increase reliance on fossil fuels.

Conservation of biodiversity is, of course, a principal aim of the entire movement for sustainable development. Proposals for biodiversity generally reflect the principles involved in the biodiversity convention, but do not elucidate the contractive framework facilitating access to national genetic resources in return for (resultant) biotechnology transfer. The use of Environmental Impacts Assessments (EIAs) for evaluating projects likely to impact biodiversity is advised: The technique is, however, still difficult to translate to actual Cost-Benefit Analyses, an evaluation methodology with which policy makers and international agencies are generally familiar, because of problems of information. Further, while the use of economic incentives for conservation and sustainable use is recommended, whether the opportunity costs of conservation, i.e., the net economic benefits lost from not employing the resource to the best alternative use, should be forthcoming from multilateral sources, is not addressed. In fairness, this should be the subject of future protocols under the biodiversity convention.

The document points to the emerging promise of biotechnology in numerous applications, and to the potential for cooperation between ICs and DCs, in indirect reference to the contractive framework in the BDC.

The document is also a little stronger than the BDC on the issue of entitlements to commercial and economic benefits from biotechnology for indigenous peoples.

Proposals for ocean resources focus on sedimentation, pollution, injurious fishing practices, and climate change. Land based activities are asserted to adversely impact the ocean's biological resources. The creation of Exclusive Economic Zones (EEZ) are asserted to be conducive to natural resources conservation. This generally accords with economic logic.

Another significant dimension of conserving ocean resources relate to climate change impacts. The emphasis is on global exchange of research based information, in particular of small island states (SIS), which are particularly threatened. Such SIS are to be assisted for adaptation by ICs, but the document is silent on the question of liability for damage, an issue touched upon in the climate change convention.

Freshwater resources are another important subject of Agenda 21. It is recommended that discharge standards may be set as well as "polluter pays" invoked. As pointed out above, there is, however, an essential dichotomy between standards and incentive based instruments (including liability regimes) embodying polluter pays. The former do not, in general, ensure cost minimization for a given environmental standard, while the latter do so under some assumptions. The proposals also include research on the impact of climate change on freshwater supplies, and for contingency planning.

The safe use of toxic chemicals is another focus of Agenda 21. The proposals include improvement risk assessment, as well as the right of communities and individuals to information. It is recommended that Governments should employ the principle of producer liability. The rationale for this principle derives from the likely assymetry of information on risks between producers and users, including intermediate handlers.

The management of hazardous waste is another theme of Agenda 21. Policy approaches recommended in the document focus on international cost-benefit guidelines for hazardous waste production and man-

agement. By implication, the major evaluative principle is economic efficiency. The question of equity would then presumably be dealt with by national authorities, involving an assumption that impacts would be limited to national jurisdictions. The ethically sensitive issue of international trade in hazardous waste is adverted to in several ways. While no outright ban is proposed, a ban may apply when recipient countries lack the capacity to handle them in environmentally sound ways. Further, recipients are urged to treat wastes in a manner consistent with regulations in the country of origin: Presumably this will ensure a measure of reduction of impacts. Illegal trade will require penalties, legislation, monitoring, and enforcement.

Agenda 21 proposals for solid waste involve programs to minimize waste creation, reuse, and recycling, principally by incentive based instruments, international standards for environmentally sound treatment and disposal, and extending waste handling services through national planning and international cooperation. The efficient level of reuse/recycling will vary across countries, depending on their resource endowments. In general, labour rich DCs may be enabled by properly designed incentive based policy instruments, to accomplish higher levels of reuse/recycling than labour scarce ICs.

Radioactive wastes are also considered in Agenda 21. One proposal is to enhance transfer of technology for storage, transport and disposal to DCs. This is interesting because one barrier to increased investment in nuclear power generation by DCs is lack of such waste handling technology.

Strengthening the role of major groups

Political aspects

The Preamble to this chapter recognizes that the commitment and involvement of all social groups would be critical to the effective implementation of the objectives, policies, and mechanisms agreed to under Agenda 21. Separate chapters address the crucial role of women, youth, indigenous people, NGOs, local authorities, workers and trade unions, business and industry, science and technology and farmers in this

regard. The chapter on women urges governments to address directly the question of the status of women, provide girls equal access to education, reduce the workload of women, and take a variety of measures so as to secure the full participation of women in all aspects of cultural, social and public life. As regards youth, a target has been set by which governments are urged to ensure that by the year 2000, 50% of their youth are enrolled in or have access to secondary or equivalent education or vocational training programmes. The chapter on indigenous people recognises that the developed world has much to learn from indigenous people as regards sustainable development methods, and urges their involvement in the global partnership.

Economic aspects

An important dimension of sustainable development concerns is the status, entitlements, and say in family and societal decision-making, of women. It is now conventional wisdom that development programs frequently, often through neglect or oversight at the stage of formulation and/or implementation, impact women. These impacts are typically adverse, because planners and analysts are usually not sensitized to women's issues. Accordingly, the emerging sustainable development paradigm makes it imperative to conduct Gender Impact Analyses (GIAs) of project and programs, so that the women's dimension in development is fully taken account of in the policy-making process. Environmental degradation in DCs is now believed to usually have significant differential and unfavourable impacts on women. Entitlements to food may be reduced, and because of the increasing difficulty of collecting fuel, drawing water, and grazing livestock, there is increase in drudgery. Time spent on infant and child care is also reduced, adversely affecting the health and prospects for literacy of the next generation. Environmental degradation may also increase the demand for child labour time in household chores and petty tasks of livelihood, reducing further the chances of school enrollment and retention.

Proposals in Agenda 21 on actions for women's status and welfare recognize that their education and empowerment, in the family, in

society generally, and politically, can have deep impacts on population growth, schooling, infant mortality, sanitation, nutrition, and resource conservation. The proposals accordingly focus on these two objectives, i.e., women's education and empowerment.

Specific proposals include, first, formulating a strategy for eliminating constitutional, legal, administrative, cultural, behavioral, social and economic obstacles to women's participation in sustainable development and public life. Second, priority measures are recommended for disseminating gender-relevant knowledge and promoting the enhanced value of women's roles in educational curriculum. Third, measures to eliminate female illiteracy, assure universal access to girls' primary and secondary education, as well as increase their opportunities for technical and professional training. Fourth, enhancement of women centered and managed health care, including reproductive services, and making them more accessible. Additionally, equal employment opportunities and equal pay for women should be supported by day-care and parental leave. There are several further recommendations.

Other groups, identified as "social partners for sustainable development" include youth, indigenous peoples. NGOs, local authorities, workers and trade unions, business and industry, the scientific and technological community, and farmers. Proposals seek to identify their interests, and possible roles in sustainable development. In particular, it is recommended that youth be involved in decision making relating to their future. The long-standing relationship of indigenous peoples with their lands, and their holistic scientific knowledge of natural resources and the environment is recognized. Further, it is recommended that their participation in national and international sustainable development decision making should be enhanced.

Means of implementation

Political aspects

Financing of implementation of Agenda 21 was a major contentious issue before UNCED. While, in general, such financing is to come from a country's own public and private sectors, UNCED recognized that for

developing countries substantial new and additonal funding for sustainable development and implementation of Agenda 21 will be required. Moreover, developed countries reaffirmed their commitment to reach the accepted UN target of 0.7% of GNP for ODA and to augment their aid programmes in order to reach the target as soon as possible. Some developed countries agreed to reach the target by the year 2000. The Commission on Sustainable Development would regularly review and monitor progress towards this target and review process would systematically combine monitoring of the implementation of Agenda 21 with a review of the financial resources available. Funding for Agenda 21 and other outcomes of UNCED is to be provided in a way which maximises availability of new and additional resources and which uses all available funding resources and mechanisms. The summit called for "special consideration" to be given at the forthcoming meeting of IDA Deputies to the statement made by the President of the World Bank in the UNCED Plenary, in which he had made a compelling case for providing IDA with additional funds to help the poorest countries meet their environmental objectives. Developed countries and others in a position to do so are to make initial financial commitments to give effect to UNCED decisions, and are expected to report on such plans and commitments to the 47th UNGA. In turn, developing countries are expected to begin drawing up national plans for sustainable development to give effect to UNCED decisions. While UNCED was never meant to be a pledging Conference, it is noteworthy that some developed countries indicated at it specific financial commitments for enhancing the capacity of developing countries to tackle environmental and linked developmental issues. Japan, for example, will increase aid for sustainable development to $7-7.7 billion over the next five years. The EC pledged $ 4 billion and Germany agreed to meet the ODA target of 0.7% of GNP for development aid. The UNDP, GEF and others are also expected to provide increasing funding for environment projects. The cost of implementing Agenda 21 has been estimated at US$ 600 billion per annum, including US$ 125 billion in technical and economic assitance to be provided by the developed countries. It is, however, pointed out that these cost estimates are indicative

in nature, have been prepared by UNCED Secretariat, and were not reviewed by governments.

Agenda 21 also addresses both the issues of improved access to and transfer of environmentally sound technologies and corresponding know-how to developing countries on favourable terms (including on concessional and preferential terms as mutually agreed) and the strengthening of institutional capacity in developing countries.

A key element amongst the decisions taken at UNCED with a view to the implementation of Agenda 21 was a recommendation to the 47th UNGA to establish a high-level Commission on Sustainable Development(CSD). The 47th UNGA would determine the specific organisational modalities of the work of the CSD, including the question of its composition and membership, relationship with other UN bodies, frequency, duration and venue of its meetings, etc. The CSD would report to the UNGA through ECOSOC. The CSD would have a crucial role to play to maintain the momentum created at UNCED so as to ensure that decisions reached at UNCED are effectively carried out.

Economic aspects

The question of technology transfer is at the core of practical measures for sustainable development. Technology transfer is defined to include knowledge, goods, services, and organizational procedures. Support to DCs is asserted to be necessary to build up their economic, technical, and managerial capabilities.

The issue of IPRs protection is the central issue in transfer of environmentally benign technologies. While it is asserted that much relevant technological knowledge is not covered by IPRs (i.e., is in the public domain), the role of international business in transfer of proprietory technology is emphasised. The question of access to state-of-art technologies by DCs through facilitation and financing is emphasised, together with providing fair incentives to innovators.

The traditional policy concern in design of IPRs regimes is to trade-off diffusion possibilities (disclosure of knowledge to the public), which enhance static efficiency, with incentives for innovation, (i.e.,

property rights over created knowledge), which may motivate innovation, in order to realize dynamic efficiency. The introduction of environmental protection concerns, does not fundamentally alter the nature of this tradeoff: The benefits of enhanced environmental quality (as well as the costs, including the resource costs of R&D for environmentally benign technologies) may be valued, and inserted into the (dynamic) cost-benefit calculus. However, since DCs may value environmental quality differently from ICs, and their choice of social discount rate may (quite legitimately) also differ, a case is apparent on simple efficiency grounds, without invoking any equity considerations, for differential levels of IPRs protection in DCs and ICs. If (future) environmental benefits are valued lower in DCs as compared to ICs, and their social discount rates are also higher, both reasonable assumptions, the (dynamic) efficient levels of IPRs protection in DCs should be lower, since it is current diffusion rather than future innovation that would yield the greater relative benefits in their case. Such lower levels of IPRs protection would, however, result in reduced IPRs rents to ICs innovators.

"Capacity Building" in terms of Agenda 21 proposals is the *prima-donna* of international cooperation for sustainable development. Capacity building comprises developing a country's human, scientific, technological, organizational, institutional, and resource capabilities. Each country is urged to complete by 1994 a review of its capacity building needs. Programs should improve countries' ability to respond to long-term, rather than only immediate problems. Capacity building also, clearly, involves technology transfer.

Sustainable development involves major reorientation of the process and objectives of growth. It has assimilated the lessons of the development experience over the last four decades, and seeks to integrate poverty removal, resource conservation, different categories of equity concerns, empowerment of women and other disadvantaged groups, financial and technology transfers, research and development, besides economic growth, in a holistic framework. The entire approach is multidisciplinary, local as well as regional and global in scope, and relies on a range of institutions: Governments, markets, NGOs, and others. The

question of enhancing the human capital resources of countries, their knowledge base, and institutional capabilities is obviously crucial to this effort.

Cooperation in capacity building is not a straightforward North-South affair. DCs too possess significant resources of human capital and know-how, and South-South, as well as regional cooperation, are alternative approaches. These may also be more cost-effective than a preoccupation with North-South capacity transfers.

Conclusion

Agenda 21 represents a serious attempt at harmonizing current understanding of the development process and environmental protection, with political perceptions and priorities. These could change over time, and accordingly Agenda 21 is designed as a dynamic document.

Apart from questions of provision of new and additional financial resources and technology transfer, a crucial element in effective implementation, is national capacity building. The building up of technical skills, administrative capacity, policymaking siklls, and institutional design is a major focus of the proposals, in which there exists considerable scope for multilateral cooperation involving all sectors and players.

Capacity-building in India in the context of global environmental agreements

R.K. Pachauri, Ajay Mathur

The development of local capabilities and institutional strengths lies at the core of promoting development in a sustainable manner in the poorest regions of the world. Capabilities and capacities have to be strengthened not only in the scientific and technical field but also for planning at the national level and, of course, at the most decentralised grassroots level as well. In this regard the record of several multilateral and bilateral organizations has been nothing short of a disaster. The favoured approach has been to engage a group of consultants from countries in the north, often with mediocre skills and inadequate familiarity with local conditions, to carry out studies and consulting assignments by "parachuting" them into a country for a few weeks at the end of which they are supposed to have identified all the development problems of the country and also to have evolved solutions to eliminate them. What is left generally at the end of these consulting assignments is a voluminous report on strategy which is neither of value as a professional exercise nor of direct use to the organizations in the country for devising local plans and investments. In the technological field, again there has hardly been an attempt to involve local institutions, for instance, in the development of renewable energy devices. In the absence of such an approach technological change does not get endogenized.

There is today a powerful need for setting up a network of institutions in the developing world and providing them with adequate resources for research and development on environmental subjects and renewable energy technologies and devices and their dissemination. If this approach is not adopted, the developing countries would be constrained to follow the fossil fuel path of the developed countries, even when there is a compelling economic reason for other choices based on renewable

energy sources which are becoming more and more relevant in view of technological change and environmental costs both globally and locally. But resources would again have to be found for such a programme of networking, which is not only beyond the capacity of the developing countries to harness, but which developed countries have a moral responsibility to provide at least for global environmental reasons. The Government of India can play a pivotal role in this context.

In the last two years, and particularly since the UNCED conference in June 1992 the term capacity building has been used extensively by development organizations, national governments, scholars and academics. Yet, several misperceptions and misinterpretations on the term capacity building are prevalent on a wide scale, and different entities view capacity building in different lights. Since the subject is of considerable importance to the implementation of the post-Rio agenda, it is essential to throw light on this topic and to define a set of programmes and activities that would be required to attain the aims of capacity building. One major misperception which seems to dominate the development jetset, particularly in the countries of the North, is based on the belief that capacity building is an exercise to be undertaken only in the developing countries. But it is clear that capacity building in the developed countries is as important and, perhaps, far more complex than in the countries of the South. This is so because while in the developing countries new skills and capabilities are required to be generated, in the developed countries there is a far more difficult task to implement in changing old attitudes, values and directions to be replaced with a new set of lifestyles and structures. Nevertheless, in the interests of brevity and focussing on a set of specific issues, in this paper capacity building is discussed only in the context of the India. But it is hoped that the subject of capacity building in the developed countries would receive attention in developing country institutions as well, so that the issue can be articulated by them in global forums.

A few recent meetings and discussions have taken place in different parts of the globe on actions that need to be taken as a follow-up to the Rio Summit and the subjects on which agreement was reached there

as well as those subjects on which attention was not provided or agreements were not reached in Rio. In October 1992 a Post-UNCED Seminar on "Environment & Development Policy Issues in Asia" was held in New Delhi. This seminar was attended by researchers and policy makers drawn from Asia as well as from a few developed countries. The purpose of the exercise was essentially to analyze the Climate Change Convention, the Biodiversity Convention and Agenda-21 with a view to arriving at perspectives from the Asian region for actions that need to be taken both at national levels as well as on a regional basis for Asia as a whole. In the final recommendations of the conference the issue of capacity building was addressed at some length and articulated as follows:

> *"There is a marked asymmetry between industrialized and developing countries in their respective capacity for formulating informed and cogent positions during the negotiating process. The asymmetry in capacity may have influenced the outcomes of the negotiations leading to the Rio agreements. The agreements themselves were negotiated in a relatively short period of time with the explicit objective of adoption at the UNCED. The whole process extended to a little more than a year. This was too short a period for building up institutional capacities in the several disciplines which are germane to formulating negotiating positions.*
>
> *Domestic capacity needs to be built in the relevant scientific disciplines, institutions, as well as skills in policy analysis and policy making. The process of such capacity building must commence expeditiously and involve the greatest measure of international cooperation between industrialized and developing countries on the one hand, and developing countries themselves on the other. The future course of negotiations must allow for this process to get sufficiently under way.*
>
> *The initiative for such capacity building must emanate from developing countries themselves, both individually as well as through their groupings which may be regional. The scope*

for cooperation between developing countries in this respect should not be underestimated. Cooperation in such capacity building may rely on professional networks and associations in developing as well as industrialized countries, besides intergovernmental organizations. It is essential for the IPCC and the Commission on Sustainable Development to initiate specific actions for capacity building in developing country on global environmental issues, and to ensure utilization of these capacities in their deliberations."

The main concern expressed in these recommendations is confined mainly to the arena of global negotiations, and capacity building must be undertaken urgently in this context. Governments, research organisations and even the media need to be involved in such a programme. However, in the pages that follow we have attempted to cover capacity building issues in the wider context of integrating environmental factors in development plans and activities.

It would be useful to first attempt a description of what constitutes capacity building in international development activities. In doing so the author has drawn from ideas and observations provided in a document entitled **"Institutional Development: A Focussed View"** authored by Alan Fowler for the International Institute for Environment and Development (IIED), which confines its treatment of institutional development on the subject of environment and development to the countries of the South. In doing so it paid particular attention to Africa, because as the author mentions *"Africa offers a worst case institutional scenario that provides valuable learning"*. Before we discuss what can be done in capacity building in the subject under discussion, we must first examine what has been done in the past and what gaps and distortions exist in current efforts.

The Government of India must be aware that the whole question of capacity building might also become an example of a good programme being distorted to serve the interests of organizations in the North. This fear is not imaginary, because, for instance, a proposal has been developed recently by a group of professionals in the US for a total of $ 4.5

million covering a capacity building activity in certain developing countries in Africa. Of course, it is not purely incidental that of this $ 4.5 million roughly two-thirds would go to the consultants in the US responsible for the programme, and of the balance amount the bulk would go towards travel expenses for conducting workshops and seminars on the subject. It is not clear whose capacity would be built through this exercise, but it clearly would not be the developing countries identified as the beneficiaries of this programme. Clearly, capacity building, if the major donor agencies are intellectually honest, cannot reduce a concept of such importance to the level of the ridiculous. Perhaps, other examples of what should not be done would also be relevant, without labouring the point too far. An ESMAP project in an African country envisages a project budget of US $ 321,000. The purpose of this programme is to demonstrate energy efficiency improvements in the industrial sector of the country with three principal tasks, namely, (2) performance of three energy audits for industrial firms, (2) training and sensitization activities, and (3) developing an outline for a continuation of the project. It is obvious that accountability for such projects is so weak that a large number of development assistance programmes conform to this pattern, and unfortunately at the end of the assistance provided, there is really very little left in the so called beneficiary country other than perhaps a project report and a few weeks of superficial training or sensitization programmes.

The Government of India must utilise the ability of Indian institutions to develop and strengthen networks of other country institutions in alliance on global environmental issues. The primary role and most effective action that such networks could take collectively is in keeping multilateral and bilateral development organizations honest in their interpretation and implementation of capacity building activities. Adequate but modest funds should be sought for carrying out an ongoing scrutiny of development assistance programmes for capacity building, of which we would see an avalanche in the coming years, so that the kinds of distortions referred to earlier do not continue and a mockery is not

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made of well-intentioned capacity building efforts that would form part of development assistance programmes.

How should capacity building be channelized if we wish to install capabilities and infrastructure for effectively addressing environment and development problems in the countries of the South? Firstly, we have to critically ask whether the traditional approach to institution building as the IIED paper points out, namely that of creating or strengthening public institutions, is the best approach to follow. The answer is quite obviously no, because governments have certain inbuilt constraints in functioning solely on their own in

- effectively integrating environmental considerations in development programmes,
- creating awareness at the grassroots levels, so that environment and development becomes truly a people's movement,
- providing adequate resources for environmental protection, accustomed as several ministries and departments are to conventional methods of spending that merely emphasize investments in hardware, large projects and programmes.

It is necessary, therefore, to conceive of capacity building efforts as strengthening institutions and organizations outside the government, because through the pressure and the innovative inputs that non-government organizations can provide, ministries and departments not dealing with environmental subjects themselves would have to improve and attain higher levels of accountability in this general area. But we must identify the types of actors that would be most effective in bringing about the change that is required for preserving the planet and ensuring the welfare of the poorest of the poor. For, in the ultimate analysis, unless poverty is eliminated, environmental protection would not take place and development would remain merely a pronouncement of words without action. We would like to propose a clear definition, though certainly not a separation, of three sets of actors that would form the core of capacity building activities. These are -

* Non-government organizations (NGOs), who as the term has now come to generally indicate are activist organizations and who

articulate problems and issues, acting as a strong pressure group for ensuring that unfair advantage and huge economic rents do not accrue to special interest groups at the cost of people at large.

* Grassroots organizations (GROs), who are basically activity based organizations actually implementing programmes in partnership with local organizations, people's groups and others, so that development takes place in harmony with environmental protection.

* Non-government research institutions (NGRIs), who can be described as think-tanks not of the ivory tower variety, but groups of individuals who are practical in their approach and empirical in the analysis of policies and programmes. Given the great lack of effective think-tanks in the developing countries, it is critically important that NGRIs be strengthened appropriately so that they provide a credible option for policy analysis and formulation, based on research capabilities outside of the government but not necessarily separated from the government.

The reason why NGRIs as a specific group of actors need to be supported and strengthened is because in the developing countries (as should certainly be the case in the developed countries as well), there is an urgent need for change in direction in development strategies and the articulation of new paradigms of growth. This would require substantial changes in the pattern of resource allocation, the institutional arrangements for implementing development programmes and alternatives in the very structure of the economy. No better agent for change on these subjects can be conceived of than local and domestic research institutions, who while working at the frontiers of knowledge and research capability, are fully in tune with local conditions including culture, social values, resource endowments and existing skills. The development of NGRIs, which the proposed network could focus on as a priority subject would require much closer and more frequent interaction between research institutions and the government, from which benefits would accrue to both sides. Government would gain from ongoing analysis of problems and possible solutions as well as new ideas which a think-tank

can produce far more effectively than those who are engaged in day-to-day decision making. Research institutions would gain by acquiring a practical orientation and viewing real life problems in a larger development context rather than in narrow sectoral terms.

What is proposed in capacity building efforts in the developing countries, therefore, is a three tier approach involving NGRIs, NGOs and GROs. It is quite possible that an organization or group combines all three sets of roles and activities, but any one agent working in isolation of the other two is likely to be less than effective. NGOs will remain only activists and eco-fundamentalists if they do not interact with NGRIs and GROs. Likewise NGRIs would remain theoretical ivory tower and armchair analysts if they do not interact with the other two sets of actors. And, finally, GROs would not understand the problems of resource allocation and their efficient utilization or the inter-play of interest groups in a democratic society, if they remain lost in the field without reaching outwards to the other two sets of actors.

Environment and development presupposes a high level of literacy, but the consciousness about environmental and developmental issues could be built into a mass movement which necessarily requires reorientation of government plans and priorities - a reorientation which can only come about if all three sets of agents work in concert. A brief digression into the experience with the literacy movement in India would perhaps help in proving this point.

Solutions to complex problems have to be conceptualized for implementation one step at a time. If the environment is to be protected or, for instance, a community is to see the benefits of clean drinking water, then perhaps as a first step basic education and literacy become prerequisite actions. Edgar Snow once asked Chairman Mao of China on what he considered to be the biggest achievement of China's revolutionary phase of development. It is reported that Mao paused for a minute and said *"Yes, those flies. We have eliminated them"*. In putting forward this view apparently Mao was seeing the elimination of flies as just one part of a large number of solutions which had been implemented such as the provision of proper drainage, the adoption of sanita-

tion measures and a general cleaning up of the environment. Undoubtedly, these achievements take place only after several other basic needs of society have been satisfied. Similarly, the removal of illiteracy can be seen as part of a much larger set of challenges, which a developing country faces along a broad front. It is incorrectly believed that the removal of illiteracy can only take place as a result of a major social upheaval or revolution. Outstanding examples of successful campaigns for literacy are often quoted as coming from China, Cuba, Vietnam, Nicaragua, Burma and Tanzania. A democracy such as India is never mentioned as an example of successful removal of illiteracy, largely because the effort thus far has remained inadequate in relation to the huge numbers involved. On the other hand, another democracy, namely, Sri Lanka has had far greater success than other countries on the Indian sub-continent. Yet, there are parts of India where literacy has been achieved to a level of 100%, notably in the state of Kerala along with several other regions. It would be useful to quote from the Committee for Review of National Policy on Education which examined this issue in India in 1986, *"Imparting literacy should be placed in the context of the developmental needs of the adult. Adult education programmes should be accompanied by a wide range of measures relating to health, nutrition, housing and employment needs. They should also address themselves to the issues of fundamental rights, laws, secularism and democracy. After creating awareness in respect of these essential needs and issues the adult learner himself should be expected to ask for literacy as a felt need. Instead of starting with adult literacy, the start should be in respect of creation of awareness for essential needs and from there work backwards to adult literacy".*

What is implied in this statement is the argument that literacy itself is not enough or possible in the absence of social change. Perhaps one can even go to the extent of suggesting that people remain illiterate because they do not feel the need for literacy and that nobody really has the right to impose literacy on them even through campaigns to motivate them. Hence, the best way - indeed the only way - is to ask the people themselves whether they wish to become literate in a manner

that generates confidence. In essence, the removal of illiteracy requires some of the most enlightened and sophisticated approaches that are known in the field of public policy and management. It is very clear that a society cannot lift itself up from poverty, alienation and deprivation unless it attains literacy. The sense of liberation and self-confidence that literacy imparts goes far beyond the stage of learning letters. Literacy movements have been known to liberate the poor and the illiterate in India from a sense of fatalism and to create in them a sense of confidence in a better tomorrow. The movement liberates the middle class and the educated at the same time from a sense of cynicism, apathy and contempt, which can be terribly divisive forces in any society.

To realise the benefits of literacy, one must review the recent thinking on human development. In the wide field of development economics, the most notable contribution that has been made in recent years comes from the work carried out and published by the United Nations Development Programme (UNDP) in arriving at indicators of human development as opposed to measures of economic output that have dominated thinking in the development literature since the middle of the century. The concept of human development clearly establishes that the basic aim and objective of human development is to enlarge the range of peoples' choices to make development more democratic and participatory. These choices naturally include access to higher incomes and employment, education and health and a clean and safe physical environment. All this implies that the individual must have the fullest opportunity to participate in community decisions and to fully enjoy human, economic and political freedoms. It also implies that people must have opportunities to invest in the development of their capabilities, that is, in their health, education and training. It is only then that development becomes sustainable. Undoubtedly, these objectives cannot be met unless people have the basic minimum of literacy which is essential for enlarging their choices. Understanding these issues are vital to the success of GROs working in the field and for the use of the full potential.

The UNDP has for two years been publishing the Human Development Report, which essentially explores various facets of human development and ranks different countries on the basis of a human development index (HDI). In the new HDI ranking, for instance, knowledge is measured broadly not merely by adult literacy, but also by mean years of schooling. This is an important issue, because even today about a billion adults in the world cannot read or write, and well over 100 million children of primary school age are not going to school. Human development does not go counter to economic development or growth. In fact, as the 1991 Human Development Report states, *"the best way to achieve human development is to promote more equitable economic growth and more participatory development"*. The report also states that primary education is a basic human right and should be provided free.

It would be useful to review a small experience from the national programme in India, to see how success was ensured. We would like to review the programme which has been implemented in the district of Eranakulam in Kerala. This programme started out of a movement by a small group that was established in 1977 called the Kerala Sastra Sahitya Parishad (KSSP). In October 1977 KSSP organised a long march called the science procession which travelled from one end of Kerala to the other, visiting almost 900 villages and speaking to more than 500,000 people. This procession reached every nook and corner of Kerala and was a unique venture, covering 11,000 km. of district and village roads. Several booklets were distributed among the people who knew how to read and write, so that they could join in the effort of motivating other people.

After this procession, rural science forums were set up in the villages which took up adult literacy work in the villages. A major element of this effort was indepth analysis of what had been done, to study the problem in all its aspects. The initial success of this effort was not very spectacular, because it received very little by way of government support. It was only in the mid 1980s that literacy was seen as a major element of regenerating the country's educational talent and the KSSP became active all over again.

A detailed project proposal was formulated and submitted to the National Literacy Mission. The mission accepted the project and entrusted it to the KSSP. The approved project, named **"Lead, Kindly Light"**, proposed to make all illiterates in the district in the age-group of 5 to 60 literate within a period of one year. The actual number of such people was about 174,000.

The project sought to mobilise about 15,000 volunteers as instructors and 500 as master trainers. They were not to be paid any remuneration. The reasons for this decision were two-fold: (1) the quality and commitment of such volunteers will be far greater than those who rush in to get the pittance of Rs. 100 (only 4 USD approximately) as honorarium, as given in the earlier Adult Education projects and, (2) on a national scale, enough resources would not be available to run a fully paid programme to make 200-300 million persons literate. But there was no guarantee that volunteers will come forward on such a large scale. The overwhelming response of the people in Eranakulam district towards the padayatra (procession), proclaiming the advent of the programme, gave much optimism. The actual turnout surpassed even the most optimistic estimates. More than 21,000 volunteer instructors, two-thirds of them women, and 1,200 volunteer master trainers came forward. It was apparent that the sense of patriotism and spirit of service had not evaporated and that there was still a lot of basic goodness lying dormant within society. With their help 165,000 adult illiterates were enrolled and 80 per cent of them attained the minimum level of literacy prescribed by the National Literacy.

We have provided this narrative on literacy and human development, not because non-government institutions can undertake these programmes entirely on their own. But they can help very effectively to reorient the thinking of development assistance agencies and governments at every level by exposing them to new interpretations of sustainable development and its very basic prerequisites. Or else we would continue to see good money chasing bad money.

Essentially capacity building requires the launching of mass movements that would effectively integrate environmental concerns with

development activities. In this approach, however, effective use has to be made of the most capable agents and mobilising the effort of those who are most likely to succeed. For example, if we take up the challenge of developing countries shifting to a more sustainable energy system, a challenge that India must accept as early as possible, a range of actions would need to be launched specifically including -

1) Macro policy analysis and advice - Governments, legislators, leaders of public opinion would have to be educated on the benefits of efficient use of energy, greater use of renewable energy sources and the role of innovation in changing existing patterns of energy consumption. The policy analysis package in this case would go far beyond the energy sector, because solutions lie in devising new and energy efficient transport systems, better design and construction of buildings, revised approaches to the design of habitats and the use of space in human activities, new technologies for agriculture and the like. Since energy consumption patterns in the developing countries basically emulate the experience of developed countries, a change in direction spelling out the implications for financial and capital requirements, new institutions and organizations would have to be included. As mentioned earlier, this is an area where so much needs to be done in the developed countries themselves and this, therefore, represents an area where close partnership is possible between research institutions in the North as well as the South.

2) Actions at the non-government level - This would require, for instance, motivating and helping corporate organizations to carry out energy audits and implement energy efficiency improvement programmes. For non-corporate organizations, the effort could involve information dissemination programmes, influencing local groups on taking sustainable energy decisions and, in general, working closely with organizations that are key decision makers and major consumers of energy such as transport organizations, etc.

3) Grassroots activities - These could include efforts both at producing energy in a sustainable manner, such as biomass plantations and, of course, providing technological solutions for efficient use of energy in households, farms, small production units, etc. GROs can also play a vital role in creating awareness, influencing the adoption of new values in the use of energy, and, in general, bringing about a change in lifestyles to move society on to a new energy path. This is an activity that is highly relevant to the developed countries as well, and church communities, neighbourhood groups, etc can play a useful role in this regard. In India, the experience of the literacy movement described earlier, would be a good model to adopt for grassroots action in the energy field.

In this discussion, we focus on the building up of change-generating capacity in India particularly in the light of agreements that came into existence at UNCED in June 1992. The broad aim of this change-generating capacity building is to enhance the decision-making capabilities of individuals and institutions so as to promote economic and environmental sustainability. Decision making relies on an assessment of probabilities, of costs and of benefits. Decision makers base their decisions on their skills, experience, and "intuition" (the sum of their intimate knowledge of a particular system), and largely rely on external information in the form of pre-digested summaries of facts and opinions. The aim of capacity building in India, therefore, should be to enhance the capabilities of individuals so as to enable them to relate their experience to the decision-making process in a more analytical manner (i.e., formalize intuition so that it could be disseminated); enhance the level of awareness of individual decision-makers about the impact of their decisions on other firms and on the country (i.e. enlarge the ambit over which the cost and benefits analyses are carried out); and develop institutional structures that provide for the rapid availability of analyses to aid in decision making.

1. Global

Capacity building to tackle global environmental challenges - Capacity in this area is essential for addressing global environmental problems and to equip developing countries with the right level and type of expertise for addressing the task of negotiations under the Climate Change Convention, which has come into existence after UNCED at Rio. In particular, the Climate Change Convention requires the developed countries to bear the "full agreed incremental costs for mitigation for greenhouse gases", and this is a subject which rightly should be agreed on jointly between developed and developing country organisations. The concept of cost, of course, is not simple and would require considerable research, extensive collection of data and the resolution of methodological problems as an essential prerequisite to producing useful outputs. There is a danger that with the growing global interest in quick numbers and pressure from several funding organisations to arrive at cost estimates for ranking opportunities, several misleading and inaccurate estimates of costs may be produced to serve the very limited purpose of global negotiations and financial transfers. However, such methodologies cannot be developed overnight, and would probably follow an evolutionary process. In this context it would be useful to mention the work of the Asian Energy Institute (AEI) which has developed order-of-magnitude estimates of costs for a number of member Asian countries and Brazil.

On the basis of analysis carried out by the Asian Energy Institute, one can identify several target sectors and activities as well as target technologies which would be relevant to the assessment of mitigation measures and their costs. A cross country comparison reveals that in all the countries included in the study the industrial sector consumes a major share of the total energy supplies. Therefore, improvements in energy efficiencies in this sector could lead to significant savings in CO_2 emissions. Obviously the particular measures adopted differ across countries. For example, in India improved housekeeping, installation of energy efficiency equipment and better instrumentation may well result in saving of 88 million tonnes of carbon (MT-C) at an investment of $ 3.5 billion. In Brazil the package for the industrial sector includes better choice of electric motors (in terms of their size), appropriate design of the internal distribution electric network, installation of small

size transformers in parallel with the large ones, and correction of load factor, requiring an investment of $1 billion and saving 4.8 MT-C.

The electricity sector presents considerable opportunities for emissions reduction in all the countries studied. There is, for example, large scope for reducing transmission and distribution losses which range from 22% in India to 40% in Bangladesh. Thus, if these losses were reduced to 16% by the year 2000 in India, an investment of $7.2 billion would yield a reduction of 210 Mt-C of carbon (assuming that the entire reduction in CO_2 emissions is attributed to reduced power generation by coal based thermal plants). In China, an increase in the shares of pressurized fluidized bed boilers and combined cycle plants (oil based) which are more energy efficient than the conventional plants can together save 14.7 MT-C at a total investment of $ 372 billion.

What is mentioned above is purely illustrative of priorities in sectors and activities which would need to be tackled in any capacity building effort in India, but a research agenda is perhaps best evolved through some interaction between researchers and policy makers. Also a research agenda once established may require frequent changes and modifications over time, and it is important for Indian organisations and institutions to network with other institutions, particularly in the developing countries.

The other area in which expertise would need to be established in India would be in respect of the implementation of the Montreal Protocol. Among all the developing countries, the importance of this subject is very large for India, which is a manufacturer of CFCs, and is also exhibiting rapid rates of growth in the stock of air-conditioners and refrigerators, etc. The changeover costs from CFCs to substitutes in India, as in other developing countries, would include the costs of retooling of industry, changes and design of equipment, and, of course, the costs of substitutes that are to be used in compliance with the Montreal Protocol. Disputes are likely to occur between the magnitude of these costs to the developing countries, since the developed countries are due to provide full costs of changeover as specified in the Protocol. Capacity building in this case would involve research institutions, industry and of course, government.

Government would need considerable help with the decision processes associated with long-term global environmental issues, e.g. the greenhouse effect and the CFC-phase out. Availability of well-validated

information is of crucial importance for the government to develop national strategic plans to ensure the continuation of economic and development objectives. One of the most difficult tasks facing politicians and planners in attempting to develop strategies to cope with limiting greenhouse gas emissions and in phasing out CFCs is the meshing of the very large time scales of politics and of global change. Specifically, the physical and chemical processes associated with increasing global environmental degradation have time scales comparable to human lifespans. Consequently, strategic planning has to be undertaken in perspective with the long-term economic and environmental interest of the country.

This would involve a generating awareness in the public of the need of the government to tackle the problem. This would require a variety of activities, ranging from public education meetings to investing in greenhouse-oriented research projects. Media, NGO, research and political awareness have put India in a prime position to assume a leading role in political and planning strategies, specially in developing countries. For these reasons, Indian scientists should be able to provide information and analyses to senior politicians and planners so as to assist them in decision making. Capacity building for this purpose is also required in the information sciences so as to develop systems that can provide updated information to the public, researchers, media and the planners.

2. Local

The development of capacity in relation to local environmental problems requires the ability to carry out environmental impact assessments of a range of activities right from the generation of power and establishment of industrial units to cooking and household activities involving the use of non-commercial biomass fuels. Capacity building for improvements in the rural cooking cycle are discussed later, but it is important to observe that for environmental impact assessments, capacity building measures would require

a. The development of expertise in consulting organisations, research institutions and independent bodies who would increasingly be called upon to assess the environmental implications of projects, particularly with growing public awareness. The Sardar Sarovar

project in India is a good example where the wisdom of organisations such as the World Bank, the Government of India and State Government of Gujarat has been called into question by a popular grassroots movement opposed to the project.

b. Training of engineers and managers dealing with a range of industrial projects including those involved in the production of energy. It is not enough to find fault with a project once it has been conceptualised and designed. Environmental considerations have to be integrated at the design stage itself, and this would require a massive educational effort involving those who are involved in the identification, design and implementation of such projects.

c. Information dissemination and awareness creation - Environmental considerations would require a great deal of transparency of decisions in a number of activities and educating the public on what is rational and what is not. At present, unfortunately, there is a large gap between those who are involved in the implementation of projects and the NGO community that opposes all manner of economic activity. The public has to be informed about rational choices and their costs and benefits which translate physical environmental measures into economic terms. The capacity of organisations and institutions to convert complex analysis into simple information is a subject of great importance to the implementation of Agenda-21.

Capacity building at this level is an order of magnitude more complex than that for addressing global environmental challenges. This capacity building has to reflect a greater understanding of linkages and environmental impacts in decision making at various levels in the industrial and commercial sectors, as well as in personal lifestyles. The process of moving towards sustainable lifestyle patterns is necessarily a long-term one as it involves changes in attitudes and behaviour. This, to a large extent, could result from a diffusion of the processes that occur in the industrial and commercial sectors as individuals would tend to use the same sets of values and attitudes in personal decisions as in professional ones. Capacity building in the industrial and commercial sectors has largely to be aimed at enhancing human-endowed capabilities within firms to handle technological and trade-pattern changes in a manner

that is both economically and environmentally sustainable. This capability is characterized by three major features: a) a reasonably long-term business horizon; b) awareness of the upstream and downstream linkages associated with the operation/decision that an individual is involved in; and c) awareness of, and relatively rapid access to information and analyses that are necessary in decision making.

Business time horizons are largely dependant on the overall economic situation in the country, the fiscal policies of the government, and the structures of the capital market. On the economic front, India is a rapidly growing economy with a societal desire to enhance the quality of life for its citizens. These imply that there is a resultant emphasis on the expansion of installed capacity to increase the production of goods and provision of services. Capacity building for sustainable development would require that this emphasis is tempered with an equivalent emphasis on the efficiency with which natural, financial and human resources are utilized in installed capacity expansion. This is brought about by the fiscal policies of the government which would have to ensure the linkage of resource allocation with efficiency norms. Taxation structures, capital availability and pricing mechanisms are best utilized to ensure efficiency of resource use. The overall scarcity of resources in developing countries such as India, associated with constraints on technology imports (because of foreign exchange limitations), also imply that continual indigenous technology, upgradation and innovation is required and is to be encouraged. This again needs the development of human capabilities which are achieved through the dynamic interplay of skills, experience, and training. These are expensive capabilities and hence it must be in the interest of firms to invest in their development. This interest is again ensured by macro-economic policies that promote competition, ensure fair prices, and effectively institutionalize environmental efficiency criteria in resource allocation policies.

The structure of the financial markets is another major feature that influences corporate decisions regarding business time horizons and ensures their interest in developing human capabilities to manage change. The financial institutions are the key actors in ensuring the linkage of efficiency and environmental criteria with investment decisions. Innovative financing mechanisms would accelerate this process, these mechanisms include concepts such as venture capital availability

(to which there are strong legal constraints in India), consortia funding (which promote linkages between manufacturers, users, and R&D/consulting organizations), etc.

The economic imperative of installed capacity expansion in industry has resulted in effective delinking of decision-making in firms from the resulting implications in both upstream and downstream industries and markets. This leads to situations that are environmentally and/or economically ridiculous. The emphasis on electricity generation expansion as resulted in massive environmental damage due to expansion of open-cast coal mining (which was necessitated by the need to rapidly enhance coal production), as well in economic inefficiency due to the extremely inefficient use of electricity in nearly all applications, specially in the agricultural sector (largely because of electricity pricing does not reflect the true costs incurred in its generation and distribution).

Emphasis on downstream and upstream linkages can be enhanced through the consortia funding approach mentioned earlier, enhancing competition (so that no corporate entity can take input availability or product consumption for granted), and mechanisms/regulations to ensure fair pricing and compliance with environmental regulation. These institutional linkages must be based, as far as possible, on the self-interest of the actors, rather than on monitoring and control. The environmental liability concept (in which all industries are required to purchase environmental insurance, and the insurance companies compensate those who are affected because of an industry's environmental impacts) is a good example of such a linkage, as opposed to the existing monitoring and regulation framework alone which promotes corruption and non-compliance.

Achieving longer-term business horizons and ensuring consideration of upstream and downstream linkages during decision-making in firms requires that the decision makers are aware of the consequences of their decisions; possess the tools to analyze information so as to make these decisions; and have access to the required information. In order to assess the training needs so as to develop this it is useful to identify who these decision makers are, and what type of decisions do they make. Broadly speaking, there are two types of decision makers: those associated with corporate policy, and those associated with the operation of the firm whose decisions help in maintaining and increasing the efficiency of

operations within the firm. There would be further divisions within these two broad categories based on the type of activity that a firm is involved in, e.g. manufacturing, trading, financing, etc. The number of people covered by these definitions are obviously very large; there is, therefore, a need to create institutional configuration that promote capacity-building through formal training, as well as through routine professional interaction. The key or linchpin organizations in this regard are financial institutions and consulting organizations. They are relatively fewer in number and interact with large numbers of clients. Their multiplier effect (of encouraging capacity building through professional interactions) is therefore large. Professionals in these organizations should be statutorily required to undergo training that would enhance their capabilities in the perspective of sustainable and environmental development.

In the case of consulting organizations, there would be a need to develop training programmes for specific sectors or groups of sectors, e.g. for heavy chemicals, metallurgical industries, the energy sector, and so on. The trainers for these linchpin organization-training programmes should have technical experience, as well as awareness of the larger economic and environmental linkages. The development of these trainers should be the prime responsibility of the government. A strategy that could be adopted would be to establish expert groups for each sector under consideration (with three to four members in each group) with the charter to develop an effective syllabus for the development of trainers. The training courses so identified could be carried out through the existing research and training institutes in the country. The trainers could then form independent training organizations, or become part of existing research/training organizations, who would then offer the statutorily-required training programmes for professionals working in the linchpin organizations. Professionals from other organizations (non linchpin organizations) should also be encouraged to attend these training programmes through incentives such as corporate tax-breaks, etc.

To summarize, capacity building for internalizing sustainable development practices in the industrial and commercial sectors in the country would require fiscal policies that promote competition, ensure fair pricing, encourage resource allocation linkages with efficiency norms, and a relatively diverse capital market. Simultaneously, these should be

complemented with enhancing the human-endowed capabilities in firms through the development of training programmes that enhance the capabilities of individuals in firms to make decisions that are economically and environmentally sustainable. For this purpose, the government should encourage establishment of a range of training programmes for individuals in business organizations, both at the policy and the implementation levels. The policy level programmes would focus on creating the need to internalize long business time horizons and consideration of upstream and downstream linkages in business decisions. The implementation level programmes would focus on need for the continuous enhancing of resource-use efficiency in the operation of the firms. The training programmes would especially emphasize the training of professionals in linchpin organizations (financial institutions and consulting firms which have a multiplier-effect through professional contacts with a large number of clients). These training programmes could be provided by a range of organizations where the trainers have themselves been trained at specialized programmes which have been developed at the national level.

3. Rural

The problem of rural areas and capacity building to ensure the sustainability of natural resources is characterised by special sets of problems. Much of the degradation of natural resources in rural areas, which is inhabited by the vast majority of the population of India takes place on account of the pressure of fuel and fodder needs of the poor. Of these, perhaps fuel problems are the most acute in several parts of the country. In fact, India could develop innovative solutions that are relevant to biomass energy problems round the world, which are growing in seriousness and severity.

In order to assess the dimensions of this global problem from the perspective of a transition to conventional energy sources it has been estimated that the total consumption of traditional fuels worldwide is currently 18.726×10^6 TJ. The efficiency of use of this quantity is generally at a level of 8%, yielding, therefore, useful energy output of barely 1.498×10^6TJ. If this quantity of traditional fuels was to be replaced by conventional fuels, which normally would permit a device efficiency of 50%, this could be achieved through a consumption of 35.78

million tonnes of oil equivalent (MTOE) of petroleum products annually. In other words a total consumption of about 1.2% of the total world production of petroleum would be sufficient for reducing 50% of the traditional fuels used throughout the world. At a cost of $ 20 per barrel of petroleum this would require a total expenditure of around US $ 5 billion annually. Such higher consumption of petroleum products in several countries would involve import of refined products, particularly kerosene and LPG, but in some cases there may be a preference for enhancing indigenous refining, which would involve additional investments in new refinery capacity. The government or the petroleum industry in the country concerned would have to mobilise such investments as required. In addition, consumers would have to make investments in new stoves and connections to use the petroleum product in question for reducing traditional fuel use. Assuming costs that are applicable to India, we have estimated the total level of such private investments of be somewhat in excess of US $ 2 billion on a global basis. It must be emphasized that such an investment is generally beyond the capacity of the poorest people of the world who would really be the target group for such a programme.

The computation above is presented only to outline the dimensions of what is possible and desirable and to emphasize the fact that this is a target well within the reach of the global community. However, it would not be possible to achieve success with any such global programme unless appropriate investments are mobilised through channels which would ensure the success of such an initiative. Even more important than the investments themselves would be the creation or strengthening of institutions and infrastructure in these societies both at the national as well as the grassroots level. In essence, local institutions may have to ensure the distribution of petroleum products as implied in the programme mentioned above. Then, we are also confronted with a more difficult challenge, namely that of ensuring that those who receive this benefit are also able to pay for the fuel supplied. This in the case of women, who are currently spending time in collection of fuelwood, could be attempted through an employment programme which has a commercial objective, and which, in essence, supplies fuel for work to monetize the transaction at the level of the user. This, of course, is a difficult task to accomplish and would require a new dimension being added to develop-

ment programmes at the grassroots level. Its success would lie critically in a bottom upwards approach rather than a centralized effort which is conceptualized and controlled at the top. What this implies in a real sense is the articulation and implementation of a new paradigm for economic development among the poorest communities of the world. But nothing short of such an approach is likely to work. This is not suggesting the adoption of a grand national plan of action. But in the initial stages of such an effort, the implementation of a few pilot schemes could be established to become the nucleus of a much larger national effort.

In discussing the problem of biomass energy used largely by rural populations in India we have only covered the very basic requirement of energy for cooking and heating applications. Other major end-uses for which energy is largely deficient among the poorest masses of the world are in respect of lighting and motive power. The conventional approach for lighting throughout the world is through investments in expansion of electric power grids often with heavy subsidies which are becoming financially unsustainable in several countries. Given the high subsidies which permit the continuation of low tariffs of electric power in rural areas, the acceptance of alternative energy devices based on renewable forms of energy become financially unattractive to the consumer. Subsidies in rural electric supplies have, therefore, become a major barrier in the spread of renewable energy technologies in several parts of the world, where they are already becoming viable in economic terms. Here again the absence of local institutions for managing energy supply and distribution and the predominance of large electric utilities whose traditional practices favour large grid expansion, would over time become a major constraint. What applies to the distribution of fuels for cooking and the need for the development of local institutions applies with greater force to the case of renewable energy technology dissemination. The development of local organizations and skills in rural areas for promoting the use of renewable energy sources is an important forerunner of development in these areas. Wherever renewable energy projects have been executed in the past they have generally followed the approach of technologies being developed in the countries of the north or on a centralised basis and hardware being dumped in remote rural locations without the development of local infrastructure and expertise. It is no surprise, therefore, that we find most of these projects resulting in abysmal

failure. India must chart a new path in technology development suitable for rural areas and in evolving institutional arrangements for implementing renewable energy projects at the rural level.

We would like to conclude by mentioning an initiative that TERI has launched with support from the Rockefeller Foundation, New York and the International Academy of Environment, Geneva called the Leadership in Environment and Development (LEAD) Programme. This programme promises to be of great value in producing a cadre of motivated, enlightened and well informed leaders of business, government, the media and other sectors, so that over the next 10 years or so, India would have people in senior decision making positions fully in tune with issues of sustainable development. But much more needs to be done, and the task is so gigantic and the challenge so complex that ideas must flow in from round the globe for action in every corner of this planet. In this regard, let me emphasize once again that capacity building is a global task, and no single society must feel at the present juncture of human civilization that the problem lies only on somebody else's doorstep. The first thing we need to do as a nation is to develop the capacity to accept ideas from others if we are to proceed further.