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REGIONAL WOOD ENERGY DEVELOPMENT PROGRAMME IN ASIA
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REGIONAL STUDY ON WOOD ENERGY TODAY AND TOMORROW IN ASIA

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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cover photo: Fuelwood market in Maldives

FOREWORD

The developing countries in Asia are home to approximately three quarters of the world's woodfuel users, but have only one quarter of the forest cover in the South. That sounds dramatic, but it is not. The paradox is explained by the fact that most woodfuels in Asia do not come from public forests. It has been found that about two thirds of all woodfuels originate from non-forest land. The implications of these important findings are still to be absorbed by many policy makers.

Major implications are that woodfuel consumption is not a general or main cause of deforestation, and that woodfuel consumption will remain, whether or not there are forests. The future of Asia's tropical forests and the problems of woodfuel users are not as closely linked as is often assumed.

The present document summarises characteristics of wood energy supply and use, and provides an outlook on wood energy to the year 2010. The document presents a critical review of available wood energy data, leading to best estimates of future consumption. It also tries to estimate the present and future potential supplies of fuels from wood and crop residues. The study shows that in most countries, the actual availability of woodfuels is not the major concern; rather it is their distribution to people in need.

This point leads to recommendations to policy makers on how best to integrate woodfuel supply with other objectives, particularly in the forestry sector. The integration of woodfuel development in other relevant sectors like agriculture and energy is also strongly recommended. The document further calls for efforts to upgrade fuels from crop residues by using cost-effective technologies.

The present document has been prepared at the request of the Asia-Pacific Forestry Commission. The study is a joint effort by Tara Bhattarai, Conrado Heruela, Willem Hulscher and Auke Koopmans, with Jaap Koppejan and Joost Siteur contributing to data analysis and modelling, and Arjan Kraijo to literature research. The work continues, particularly in much-needed efforts to strengthen the available wood energy data.

Willem Hulscher,
Chief Technical Adviser

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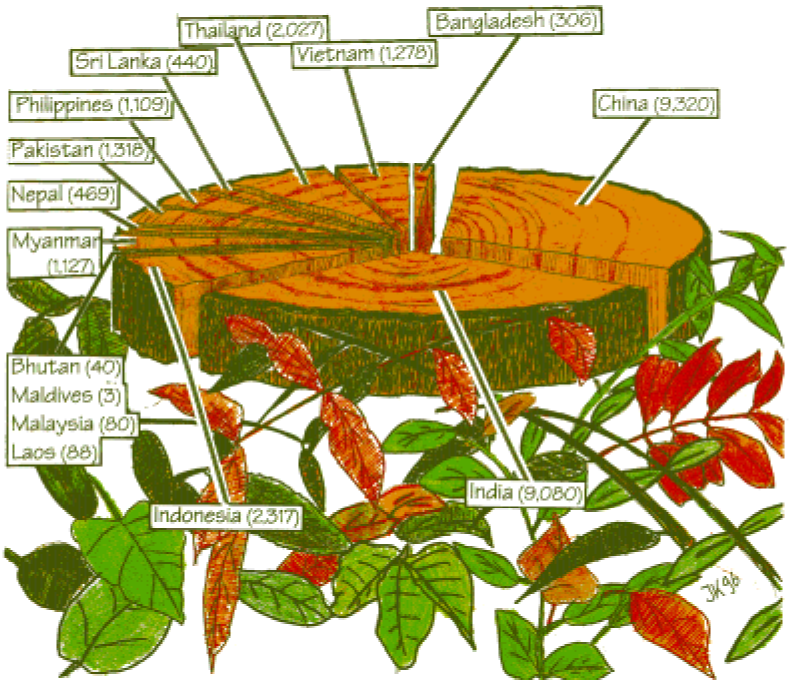
EXECUTIVE SUMMARY



The economic value of woodfuels in millions of US dollars per year

Purpose of the Study

The Asia-Pacific Forestry Commission (APFC), at its meeting at Yangon in January 1996, agreed to a proposal for a Forestry Sector Outlook Study for the Asia-Pacific Region. The Study was to include scenarios for wood energy demand and supply in the context of overall energy transitions in the region.

The present study on 'Wood Energy Today and Tomorrow' has been prepared by RWEDP to contribute to the Outlook Study. It mainly considers the 16 RWEDP member-countries in Asia, which are Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam. The study links with the work initiated by FAO's Wood and Non-Wood Products Utilisation Branch (FOPW) on Wood Energy Today and for the Future, which addresses the present wood energy situation at national, regional and international levels and possible wood energy scenario's for traditional as well as modern uses.

The study is aimed at policy makers in the forestry sector, but also touches upon policy issues in other sectors, e.g. agriculture, rural development, energy and environment. As yet, sufficient wood energy data are not available to enable woodfuels to be included in common energy modelling and supply-demand balancing. RWEDP is in the process of remedying this by continuing to collect and validate data. The study addresses energy issues only, and builds on available data on related subjects like population, landuse, demand and supply of timber products, etc.

Wood Energy Today

Role of Woodfuels

Woodfuels are an important commodity from forests and other tree production systems. Each year, the 16 RWEDP member-countries meet about 10,000 PJ of their total energy consumption by woodfuel (which averages to 30%, excluding China). It has been estimated that woodfuels represent an economic value of about 30 billion US$ per annum. The current financial value of total industrial roundwood production in the same countries is about US$25 billion per annum. In Asia, the consumption of woodfuels is increasing in absolute terms by about 1.6% each year, and this trend is likely to continue in the foreseeable future.

Sources of Woodfuels

Woodfuels consist of woody biomass, i.e. stems, branches, twigs, etc., and saw dust and other residues from logging and wood processing activities, as well as charcoal from these sources. The primary sources of woodfuels are both forest and non-forest land. Forest and other wooded land includes natural forests (including degraded forests), scrub lands, wood and timber plantations and woodlots. Non-forest land here includes agriculture land, agro-forestry systems, waste land, line trees, home gardens, etc. The ratio between woodfuels originating from forest and non-forest land is generally not known, but data from 7 RWEDP member-countries indicate that about 1/3 of the woodfuels originates from forest land, and about 2/3 from non-forest land. Typically, non-commercial sources of woodfuels are located within a 20 km radius from the end-users, and commercial sources within a 100 km radius from the market.

Secondary sources of woodfuels are residues from logging and wood processing industries, but also recycled wood from construction activities, packing crates, pallets, driftwood, etc. In some areas recycled wood supplies as much as 20% of total woodfuels.

The "Fuelwood Gap Theory" Rejected

In the 1970s and 1980s it was generally assumed that all woodfuels originate from public forest land. This lead to the 'fuelwood gap theory' from which it was concluded that non-sustainable yields were taken from forests to meet wood energy demands. The theory resulted in the assumption that woodfuel use was a root cause of deforestation. But now, ample evidence exists to prove that the theory is false and that, except for localised areas, woodfuel use is not a main cause of deforestation. The indications are that a major cause of deforestation is the ongoing conversion of forest land into other land uses, particularly agriculture. This is generally carried out by planned forest clearing or results from gradual processes of forest encroachment.

Consumption of Woodfuels

Woodfuels are consumed mainly by rural populations, though substantial amounts are also consumed in most towns and cities. The larger part of the consumption is accounted for by households, but numerous industries and services are based on woodfuels. In the domestic sector consumption is spread over lower, middle and higher income groups. Even in conditions of increasing urbanisation and fossil fuel penetration, the large majority of the households in Asia use wood or other biomass fuels. In all RWEDP countries total consumption is still increasing, and in several countries woodfuel consumption per capita is also increasing. In fact, consumption per capita is very site-specific and influenced by factors like climate, household size, availability and reliability of supply of the various fuels and their potential substitutes as well as their costs, the appliances required for utilisation, and culture and tradition.

Most consumers in the domestic as well as the industrial and service sectors still avail themselves of relatively simple and inefficient technologies for combustion. Efforts are being made to disseminate improved technologies. Where successful, the efforts result in improved quality of life, particularly for women, or improved viability of traditional industries and services. However, as yet no evidence exists that the introduction of more efficient conversion technologies would have lead to reduced demand for woodfuels from any forest resource base.

Substitution

Apart from wood, agricultural land produces biomass residues, part of which is available as fuel on an environmentally sustainable basis. At present, the main biomass fuels are crop residues like bagasse, rice husks and straw, coconut husks and shells, palm oil kernel, shells and fibre. Wood and other biomass fuels (as well as animal dung used for fuel) can substitute for each other, though most consumers have a general preference for wood over other biomass. In terms of energy content per ha per annum, the sustainable production of biomass residues available for fuel from plantations and agricultural land is about 30% of the sustainable yield of woodfuels from natural forest land. Non-sustainable production of potential woodfuels due to deforestation aggregated for the 16 RWEDP member-countries is about equal to the present woodfuel consumption (with variations per country from 10% to 1,400%). In RWEDP member-countries woodfuel represents about half of all biomass fuel consumption in energy units.

Woodfuels can also be substituted by fossil fuels, but this is not observed as a major or general trend in RWEDP member-countries (with notable exceptions). Rather, the current overall accelerated use of fossil fuels in Asia is mainly due to additional productive and consumptive activities in the modern sector of Asian economies. Such use is largely in addition to the wood/biomass fuels, rather than a substitute for them. The widely used term 'fuel transition' is often misleading, because what is actually going on is better described as 'fuel complementation'.

Environmental Aspects

Adverse environmental impacts of woodfuel use are due to unsustainable extraction from environmentally sensitive areas, which can lead to degradation of watershed and catchment areas, loss of biodiversity and habitat, etc. However, if the supply source is properly managed, woodfuel can contribute positively to the local and global environment. Woodfuel is CO_2 neutral, provided the rate of harvest equals the rate of re-growth. When wood and other biomass resources are properly valued by local populations their sustainable use contributes to the economical management of the local environment.

Wood is very beneficial for the global environment. It can be estimated that the net effect of woodfuel use in RWEDP member-countries in 1994 implied a saving of about 278,000 kton CO2 which otherwise would have been emitted into the global atmosphere. If LPG is the hypothetical replacement of woodfuel the CO_2 saved will increase to 349,000 kton in 2010. These figures can be translated into costs avoided for recapturing the CO_2 and amount to 14 billion US$ saved in 1994 by woodfuel use in Asia, and 17.5 billion US$ saved in 2010. If coal is the hypothetical replacement of woodfuel the figures would double.

Social Aspects

Woodfuel supply implies labour for growing, harvesting, processing, wholesaling, transporting and retailing the product. Per unit of energy, the labour involved in these woodfuel businesses is about 20 times larger than for kerosene. Woodfuel business is the main source of income for about 10% of rural households, and for about 40% of their cash earnings. In times of hardship, or when harvests are insufficient for subsistence, the opportunity to generate income in woodfuel business provides a safety-net for poor persons, many of whom are women.

On the demand side, woodfuels are a basic commodity serving the daily needs of some 2 billion people in RWEDP member-countries. However, access to the fuels is very skewed. In areas or times of scarcity, landless and unemployed people and low-wage earners suffer from high prices or the non-availability of woodfuels.

Data Availability

Because of the site-specific and dispersed production and consumption of woodfuels (which are partly non-monetized), it is extremely expensive and time consuming to collect reliable and systematic data on woodfuel supply and demand. International organizations do not avail themselves of such data, and neither do most national organizations. Data on the same country published by different sources are largely conflicting e.g. by a factor 3 or more. This is true also for industrialised countries. Sometimes data published by the same national source are also conflicting. It is further noted that in energy balances published by national sources, data on the supply of woodfuels are usually worked back from stated consumption figures. Therefore, most supply figures do not provide independent sources of information.

Data published by FAO are derived from baseline estimates made before 1961. For the RWEDP member-countries, these estimates have been annually updated under the assumption that the population elasticity of consumption is 1.000. Occasional surveys under the World Bank/UNDP ESMAP programme in the early 1990s revealed discrepancies of more than 100%

with the FAO data. (It should be noted that such an occasional survey in one country can cost several million US$.) Most country-level data on woodfuel consumption is based on ad-hoc surveys, and often industrial woodfuel consumption is not covered.

Prices

Prices of woodfuels vary, depending on markets. Part of the market is still not monetized (in most places some 70%). Commercial markets are generally found in cities and towns, but also in villages, where fuelwood is traded. Local prices are largely determined by opportunity costs of labour and resource availability, which generally does not reflect the real economic (including environmental) costs. A typical price in RWEDP member-countries is 40 US$ per ton. Stumpage fees can be anything between 0 and 20% of retail prices.

A significant increase in the usual price can be due to local scarcity, which implies that more time or labour is required to bring the fuel from a distant source to the consumption centres. For the more well-to-do consumers, price increases are generally not a reason for switching to fossil fuels (convenience of fossil fuels is) or another fuel. For poor consumers a price increase can be a reason to resort to cheaper, lower-grade biomass fuels.

Anecdotal evidence indicates some correlation between international oil prices and local retail prices of woodfuel. However, in general prices of woodfuels remain more or less constant in real terms. A very small fraction of woodfuels is for export, which fetches a relatively high price.

Policies

Both producers and consumers usually perceive woodfuels to be a by-product of wood products. This applies even in areas where woodfuel plantations or village woodlots have been established. The perception clearly contrasts with the real economic value of woodfuels as compared to wood products. The reason for the under-valuation of woodfuels may be that the benefits are largely dispersed over time and over numerous small consumers, and that the fuels are partly non-monetized. This is in contrast to the situation of wood products, where forest departments, logging and processing companies, as well as individuals benefit from concentrated cash-flows. In other words, there are few or no powerful stakeholders in woodfuel matters.

Policy makers in the forestry sector can facilitate the sustainable production and good use of woodfuels without undermining the conditions necessary for the production of wood products. Adequate policies also support environmental management and social development objectives. To this end a number of specific policy measures in the forestry sector are identified in the present document.

Wood Energy Tomorrow

As the available data are either patchy or unvalidated, it is not possible to develop a reliable quantitative outlook on wood energy in Asia. However, important trends and qualitative aspects of anticipated wood energy developments until the year 2010 can be presented. Interpretation of the data collected under ESMAP has provided insights into the main mechanisms governing the supply and demand of wood energy. According to research conducted or commissioned by RWEDP these mechanisms still apply, and are likely to remain valid up to 2010.

Trends in Demand

The main trend on the demand side is the overall increase of consumption of woodfuels in all RWEDP member-countries by about 1.6% a year. The trends are based on extrapolations of time series of best available data which, in principle, incorporate influences of trends in relevant factors. The extrapolations do not take into account possible new effects of factors like accelerated urbanization, changes in household size and incomes, or culture and tradition because such data are simply not available. However, it is believed that the net effect of the combination of factors may be limited.

Prices

As no overall price elasticities for woodfuel consumption in traditional markets are known, it is not possible to base future demand estimates on trends in prices. In fact, it is likely that the overall price of woodfuels in real terms will remain more or less constant for the coming 5–10 years. Other biomass fuels may increasingly compete in traditional markets when their quality/price ratio improves. For modern applications, accelerated penetration of biomass fuels can be anticipated if, and when, fossil fuel prices increase substantially.

Trends in Supply Potential

Major trends regarding the supply side relate to changes in landuse, which differ for each country. The general trend in landuse change is a decrease of natural forest area of about 3.6 million ha each year (1.2%), and an increase of agricultural land of 4.7 million ha each year (0.6%), aggregated for the 16 RWEDP member-countries. The net result is an increase in total forest and agricultural land of 1.1 million ha each year, which can be attributed to changes in other land uses (wasteland, etc.). Combined with an average twofold productivity for all biomass fuels from plantations and agriculture land as compared to netural land, this should lead to an increase in the sustainable availability of total potential biomass fuels by 2010. In addition, there will be a non-sustainable supply of potential woodfuels because of the on-going process of converting forest land into agriculture and other land uses and commercial logging.

Outlook for the Demand-Supply Balance

The overall trends in demand and potential supply of wood and other biomass fuels per country are presented in this document. The aggregated results for 16 RWEDP member-countries in Asia are presented in the following tables.

Table S.1: Consumption & potential supply of biomass fuels aggregated for the 16 RWEDP member countries

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
	1000 ha	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
CONSUMPTION						
total woodfuels		**645,895**	**9,688**		**811,548**	**12,173**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	416,204	669,812	10,047	370,363	629,339	9,440
sust. woodfuel from agricultural areas	876,933	601,407	9,021	971,062	692,088	10,381
sust. woodfuel from other wooded lands	93,140	53,994	810	81,368	47,170	708
waste woodfuels from deforestation	(4,253)	605,565	9,083	(3,114)	437,710	6,566
total potentially available woodfuels	**1,382,024**	**1,930,778**	**28,962**	**1,419,679**	**1,806,307**	**27,095**
50% of crop processing residues	876,933	218,915	3,458	971,062	322,024	5,105
total potentially available biomass fuels		**2,149,693**	**32,420**		**2,128,331**	**32,200**

Table S.2: Potential supply and estimated consumption of woodfuels in 1994 and 2010 in 16 RWEDP member countries.

	1994		2010	
	Potential supply	**Estimated consumption**	**Potential supply**	**Estimated consumption**
	(kton)	*(kton)*	*(kton)*	*(kton)*
Bangladesh	8,999	9,396	9,271	13,320
Bhutan	5,946	819	5,624	1,195
Cambodia	81,565	5,375	43,827	7,553
China	598,546	219,122	639,733	252,819
India	235,167	173,412	255,729	225,725
Indonesia	439,049	54,474	394,923	67,465
Laos	46,006	2,329	38,902	3,496
Malaysia	137,301	6,187	97,777	8,216
Maldives	34	80	41	123
Myanmar	129,935	23,058	106,930	31,183
Nepal	11,444	12,787	10,304	18,378
Pakistan	22,569	34,687	21,144	52,167
Philippines	89,267	23,051	71,171	30,329
Sri Lanka	8,963	5,681	9,044	6,769
Thailand	67,030	46,069	59,157	53,390
Vietnam	48,960	29,368	42,730	39,418
RWEDP	**1,930,778**	**645,895**	**1,806,307**	**811,548**

When reading the tables it should be noted that aggregation over a wide region in Asia leads to hypothetical supply availability. In reality, fuelwood markets are extremely localised and fragmented. Still, some general observations can be made from the data presented.

From Table S.1. it is observed that by 2010 the sustainable aggregated potential supply of woodfuels still outweighs aggregated consumption. This positive balance does not depend on the accuracy of the estimates made, or on the assumptions incorporated into the estimates. A reasonable margin of error would still produce the same results. Moreover, the assumptions on supply potential are on the conservative side.

Much more important than the potential supply as such is its geographical and social distribution, since consumers may not be able to use available resources due to physical, financial and social constraints. The same comment applies to the country balances which are presented in this document. For some countries Table S.2. suggests gaps between the estimated woodfuel consumption and the potential supply already in 1994, which can not be real. The reasons are probably overly conservative estimates regarding supply, as well as complementation of wood by other biomass fuels. However, it is observed that Bangladesh, Nepal and Pakistan face pressures on their overall wood resource base, which are likely to increase.

Table S.1. further illustrates that any deforestation process generates a large additional (potential) supply of woodfuels which, however, is not required for a positive balance of potential supply over consumption. If deforestation is due to conversion of forest land into agricultural land, the process would result in a sustainable increased supply of potential biomass fuels, because generally agricultural land has a higher biomass fuel productivity than forest land.

It is also observed that at present the sustainable potential supply of woodfuels from agricultural lands more or less can meet the consumption. The same applies for the aggregated sustainable potential supply from forest lands. However, the latter are more likely to be found in remote areas, whereas the former are generally closer to the rural consumers. This may explain that fact that most woodfuels originate from non-forest land, as shown by data for several countries. When looking at the total potential supply of biomass from agricultural lands, i.e. wood and crops residues together, it is observed that this can meet both the present and projected consumption.

From Table S.1. it is further observed that, overall, the potential supply of biomass fuels in the form of crop-processing residues is substantial. It should be noted that the estimate builds on (only) half of the processing residues, leaving all field residues (which are about 4 times the processing residues) untouched. Indeed, local shifts from wood to other biomass fuels can be anticipated to increase. This implies an immediate and increasing need for further development of cost-effective technologies for upgrading and combusting traditional fuels from crop residues, and for disseminating such technologies, and corresponding managerial systems. In the longer term there may be scope for expanding modern bioenergy fuels based on advanced R&D.

Supply Policies

While the overall supply/demand balancing of wood and other biomass fuels in the region will not be a major concern, their distribution will. As in the 1990s, the scarcity of the fuels in localised areas and their unavailability to weaker consumer groups will remain serious problems. With on-going trends towards strengthening market mechanisms and widening gaps in income distribution, an increasing number of traditional woodfuel consumers both in the domestic and the small-scale industrial sector may become marginalized. Well-balanced and integrated forest policies can help to alleviate such problems.

Enhancement of supply in rural areas, where woodfuel is yet not a traded item, should be integrated into local farming and forestry management practices. Where woodfuel is mostly collected free of charge for subsistence, no prospect exists for its commercial production in the short-run. In such a circumstance, local people's participation in sustainable production and utilization of woodfuel from locally available resources (mostly from existing natural forest and shrub/scrub and waste lands, and from existing depleted natural forest and shrub/scrub lands) should be encouraged. These resources possess the potential to supply additional woodfuel production if management systems which ensure protection from open cattle grazing and fires are introduced. Also, tree planting in community wastelands could contribute to the development of new supply sources, as village or community woodlots. Therefore continuation of the prevailing programme of social/community forestry, which primarily aims to promote participatory forestry development schemes, may be the most feasible low-cost strategy to meet the basic subsistence energy needs of the poor and small farming communities in rural areas.

Conclusions and Recommendations

Conclusions

1. Wood energy is and will remain an important sub-sector in all RWEDP member-countries. The consumption of wood and other biomass fuels will increase in the foreseeable future.

2. Non-forest land will continue to be the main source of woodfuels. Wood energy use is not and will not be a general or main cause of deforestation.

3. The prime area of concern is not the availability of woodfuels as such, but their distribution to people in need.

4. The weaker groups in society, particularly women and children, are the ones who suffer most from restricted access to woodfuel sources.

5. In Bangladesh and Pakistan, as well in Nepal to some extent, present national aggregated woodfuel consumption may exceed potential national supply. National woodfuel shortages may be aggravated by 2010.

6. In India, Sri Lanka, Thailand and Vietnam, aggregate national consumption in 1994 is not limited by aggregate potential supply, but this may be the case in 2010.

7. In most other RWEDP member-countries, residues from forests and crops represent an under-utilised potential to supplement woodfuel.

8. Localised woodfuel scarcities may occur in all countries.

9. The agricultural sector has a key role to play in supplementing woodfuels by enhancing woodfuel production on agricultural land.

10. The positive benefits of an integrated wood energy development strategy include: development of private, community woodlots in private and community owned lands which are currently not properly utilized; expansion of private-, farm-, and agro-forestry areas; and support to conservation of soil, water and biodiversity.

11. For this integrated strategy to be successful, a number of issues need to be addressed which impinge upon the mandates of various sectors including the forestry sector.

12. In areas of woodfuel scarcity, other biomass fuels are likely to increase in importance as complementary sources of energy.

13. As a first approximation it can be stated that woodfuel use is carbon neutral, i.e. there is no net emission of carbon into the environment.

14. Thanks to woodfuel use in Asia, potential environmental costs amounting to at least 14 billion US$ in 1994, for recapturing CO2 from the global environment were avoided. These will increase to 17.5 billion US$ in 2010.

Recommendations

1. The social, economic and environmental roles of woodfuels produced in both forest and non-forest areas should be recognised and woodfuels should be treated as an important sub-sector which needs to be developed.

2. Wood energy development should be integrated into rural energy supply strategies and pursued as a common task for all relevant sectors, e.g. agriculture, forestry, rural development, energy and industry sectors. Co-ordination among the sectors concerned should be strengthened.

3. Woodfuel should be seen as an important product in its own right rather than just as a by-product from agriculture land. Integrated woodfuel production on agriculture land should be promoted.

4. Current reforestation and afforestation efforts should be continued. Natural forest management with people's participation should get high priority in areas where woodfuel is not (yet) a tradable commodity.

5. Prevailing rules and regulations which hamper wood energy development should be reviewed. These relate to land ownership and holding, tree tenure, tree planting and harvesting in private and community lands, transportation and trade of wood and related products produced by the private sector or local communities.

6. The selection of fast-growing tree species for wood energy crops, identification of appropriate provenance to match specific conditions, and improvement of the survival and growth rates of trees at degraded sites and waste lands, should be supported by further R&D.

7. Infrastructure should be developed further in areas where woodfuel is already a traded item and where potential exists for supply enhancement to meet the existing and growing market demand.

8. The effective use of by-products and residues from wood industries, partly by converting them into modern wood energy, should be encouraged to reduce wood waste and supply additional fuels.

9. R&D for upgrading and combusting fuels from crop residues and other loose biomass should be promoted. Households as well as traditional industries should be encouraged to use them.

10. More key data on wood energy supply should be collected to support wood energy policies.

11. Wood energy databases should be established at regional, national and local levels. Private and public sector agencies related to wood energy development should be given access to information to support their activities.

12. Wood energy subjects should be integrated into the training curricula of relevant sectoral education and training programmes.

13. The priority within wood energy conservation programmes should be the supply of convenient, healthy and attractive household stoves at affordable prices, so as to reach the maximum number of wood energy users.

14. The cost-effectiveness of wood energy development projects in Asia in terms of global CO_2 savings should be communicated to interested donor agencies

.

1. INTRODUCTION

Nexus of forestry, energy, poverty, environment, economy and gender issues

1.1 Characteristics of Woodfuel

Virtually all countries in South and Southeast Asia are major woodfuel consumers and producers. At present, some 39% of the total energy consumption in the developing countries of the region consists of wood and other biomass fuels, and in absolute terms the consumption is still increasing. Most woodfuels do not originate from natural forests but from agricultural and other land.

Unlike many other commodities, woodfuels are generally bound to local production and consumption centres and are largely not monetized. Production and consumption characteristics of woodfuels vary widely according to region or area, but a common and special characteristic is that many consumers are also producers of woodfuels, i.e. farmers and villagers. As a result, the market mechanisms for woodfuels may differ from those of many other commodities.

1.2 Policy Areas

Woodfuel development is considered an important subject for various sectoral policies, for instance:

Forestry:	To improve the management of tree and forest resources by villagers, including increasing the value added on-site through processing and marketing support;
Energy:	To develop renewable, indigenous sources of energy to contribute to diversification of the energy mix and self sufficiency in energy supply;
Poverty Alleviation:	To improve the livelihoods of rural people and those working in informal-sector activities by, for example, generating income and employment;
Environment:	To arrest the degradation of forest resources and other land use systems, through sustainable patterns of natural resource management and utilisation, and to contribute to efforts to reduce greenhouse gas emissions;
National Economic Considerations:	To make more productive uses of local (woodfuel) resources and provide an additional energy supply option for economic growth and development;
Women:	To create the opportunity for women to play an important role in planning and implementation of wood energy programmes and strategies.

1.3 The Present Study

The present study has been prepared by RWEDP at the request of the Asia-Pacific Forestry Commission. The study first addresses a number of misconceptions which commonly prevail with respect to wood energy matters (Chapter 2), and summarises present views countervailing the old “fuelwood gap theory” (Chapter 3).

Next, some selected data on current fuelwood production and consumption are presented (Chapter 4). The document proceeds with a discussion of wood energy consumption patterns (Chapter 5) and woodfuel supply policies (Chapter 6), leading to a number of recommended actions.

Estimates of future wood energy consumption are presented in Chapter 7 and balancing demand with biomass supply potential is dealt with in Chapter 8 which contains a quantitative outlook, based on best available data, up to the year 2010. The implications of woodfuel use for global warming are addressed in Chapter 9. Finally, the main conclusions and recommendations are presented in Chapter 10.

In Annex 1, wood and biomass energy data in the Asia-Pacific region are summarised, and Annex 2 shows the relationships between published fuelwood production and population figures.

It should be emphasised that the present document is based on currently available information which, however, is not a truly satisfactory basis for quantitative forecasts. RWEDP is continuing the process of collecting and analysing data on wood energy and related issues.

2. MISCONCEPTIONS ABOUT WOOD ENERGY

The importance of wood as a sustainable energy supply option and the problems associated with it are largely undervalued by planners and policy makers. Various widespread misconceptions hamper the development of the wood energy sector. The following are some examples:

Misconception	Fact
"Wood is not very relevant as an energy source"	**In fact, wood supplies about 30% of total energy consumption in the RWEDP member-countries.**
"Woodfuels are phasing out"	**No. In all RWEDP countries the consumption of wood and other biomass fuels is still increasing in absolute terms, even when their share in national energy consumption is decreasing.**
"Woodfuel has little value"	**The total value of woodfuels amounts to some US$30 billion per annum for the RWEDP countries together.**
"Only poor and rural households use woodfuel"	**Surveys have shown that in many towns and even in some metropolitan areas woodfuels are widely used by both low- and high-income groups.**
"Woodfuel is a traditional commodity only"	**At present, modern technologies are increasingly being applied to woodfuel development. Many industrialised countries are deliberately increasing wood energy use, for environmental and socio-economic reasons.**
"Woodfuels are being substituted by modern fuels"	**Generally not. Modern applications use modern fuels, which largely complement traditional fuel use.**

"Most fuelwood originates from forest lands"	**This conflicts with many survey results revealing that some 2/3 of all woodfuels originate from non-forest land.**
"Woodfuel use is responsible for destroying the natural forests"	**This assumption dates from the 1970s. Now, plenty of evidence is available to show that woodfuel use is not a major cause of deforestation.**
"Fuelwood is collected for free"	**Some is, but a lot is not!**
"Woodfuels are a gift from nature"	**Many people, particularly in Asia, treat fuelwood as a commodity which can be, and indeed partly is, produced and harvested like rice or wheat, though with a much longer gestation period.**
"Woodfuel production is a marginal sub-sector"	**Woodfuel businesses are the main source of income for about 10% of rural households, supplying about 40% of their cash earnings. Woodfuel use generates at least 20 times more local employment than energy from oil products (per unit of energy).**
"Wood energy cannot be planned because of lack of data"	**Indicative planning does not require a full set of data. This type of planning can support policy making.**
"Burning wood adds more CO_2 to the atmosphere than oil"	**Sustainable re-growth of woodfuel captures the CO_2 back from the atmosphere. The net effect on the global atmosphere is zero, unlike that of fossil fuels.**
"With respect to renewable forms of energy R&D should focus on solar, wind and hydro energy"	**Wood energy is renewable. Of the various renewable sources of energy wood provides by far the largest share in the region!**

3. THE "FUELWOOD GAP THEORY" REJECTED

Most woodfuels do not come from forests

The "fuelwood gap theory", formulated in the 1970's, implied that woodfuels were consumed on a non-sustainable basis. The "gap" indicated that in many countries consumption was larger than the sustainable supply from forest land. It was then concluded that deforestation and forest degradation were largely due to fuelwood harvesting. This, of course, raised a lot of concern among national and international agencies regarding the future of forests.

When the fuelwood gap theory was proposed data on the origins of fuelwood were scarce and it was assumed that all fuelwood originated from forests. However, now that much more data have become available an entirely different picture has emerged. We now know that the majority of fuelwood (over 60%) originates from non-forest sources and the supply from these non-forest sources appears to be sufficient to "fill the gap".

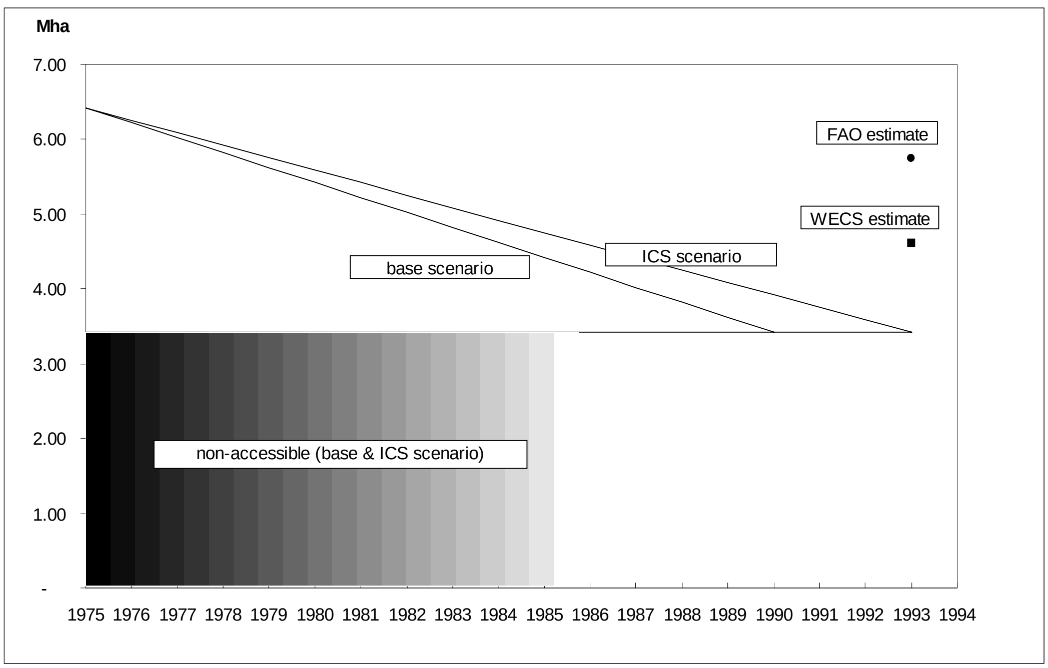
The foregoing implies that fuelwood harvesting from forest land is not necessarily non-sustainable, and that fuelwood use is not necessarily linked to deforestation. Now, fuelwood use is no longer considered a major or general cause of deforestation, although, of course, in localised areas and under certain conditions, fuelwood use may contribute to processes of deforestation and forest degradation.

3.1 Doom Scenario Nepal

Back in 1979 the Energy Research and Development Group of the Institute of Science, Tribhuvan University, Nepal, published a study "Nepal, the Energy Sector" (ERDG, 1979). The study included predictions of the demand and supply of fuelwood, which was (and still is) the most important source of energy in Nepal. The predictions were built on the assumption that all fuelwood was derived from accessible forests, which led to an assumed 'fuelwood gap'. Two scenario's were developed, a base scenario and a second scenario based on widespread introduction of fuelwood saving stoves (ICS scenario).

As seen from Figure 1 it was anticipated that from the then estimated total forest area of 6.4 million ha, all accessible forest in the country (50% of total forest area) would be completely wiped out by the year 1990. In case of massive dissemination of improved stoves, this disaster would be delayed by 3 years only.

Figure 1: Nepal Forest Area Projections and WECS/FAO estimates



By now we know that this doom scenario based on the fuelwood gap theory has not come true, and the then available data were not correct. According to FAO estimates, Nepal still had 5.75 million ha of forest in 1993 (FAO, 1994a) and 4.61 million ha. according to the Water and Energy Commission Secretariat (WECS, 1996). In hindsight one would have to argue a long way in order to explain the current situation and still maintain the assumptions of the 1970's. The case of Nepal is not unique; also in many other countries the fuelwood gap theory has led to false predictions.

3.2 Sources of Fuelwood

As yet, few systematic data are available on the sources of fuelwood consumed. An overview of available data is presented in Table 4.2 (see p.29) below. The weighted averages show that overall **about 2/3** of total fuelwood consumed originates from non-forest land. This information was not available when the "fuelwood gap theory" was proposed.

3.3 Oversupply of Yields from Deforestation

For various countries a simple calculation suffices to, at least, throw serious doubts on the fuelwood gap theory. The calculation compares the total annual woodfuel consumption in a country with the yield from deforestation. If woodfuel need was the (or a) major reason for deforestation, one would expect that a substantial part (i.e. at least 35%) of the standing stock harvested per year would be consumed as woodfuel. For comparison, data from the period 1980–1990 were analysed. The results are presented in Table 3.1 below.

Table 3.1: Potential woodfuel production from deforestation as compared to total woodfuel consumption

1994	potential woodfuel production from deforestation *(kton)*	total woodfuel consumption *(kton)*	ratio of pot. wf from deforestation to total wf consumption
Bangladesh	1,426	9,396	0.15
Bhutan	1,678	819	2.05
Cambodia	63,311	5,375	11.78
China	58,347	219,122	0.27
India	18,999	173,412	0.11
Indonesia	181,526	54,474	3.33
Laos	21,767	2,329	9.35
Malaysia	87,754	6,187	14.18
Maldives	-	80	0.00
Myanmar	65,341	23,058	2.83
Nepal	4,258	12,787	0.33
Pakistan	4,598	34,687	0.13
Philippines	45,486	23,051	1.97
Sri Lanka	1,529	5,681	0.27
Thailand	31,046	46,069	0.67
Vietnam	18,498	29,368	0.63
RWEDP	605,565	645,895	0.94

The results for different countries like Bhutan, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar and Philippines show a large oversupply of wood harvested as compared to fuelwood consumption. Such results contradict the fuelwood gap theory. It is inconceivable that time and again people nation-wide would cut down several trees in order to use only 35% of one tree as fuel.

These results suggest that the fuelwood gap theory is suspect for other countries too.

3.4 Pakistan Household Energy Strategy Study (World Bank/ESMAP and UNDP, 1993)

Using the 1991 HESS data, total annual yields of wood were estimated at 22 million tons against total consumption for 1991 at 32 million ton. This gives an national wood deficit of 9.7 million tons. If these numbers are accepted as being accurate and no changes in the wood consumption and supply situation were to occur in the immediate future, all of Pakistan's wood resources might be anticipated to disappear in the next 20 years.

This scenario will come true if and only if a carefully defined set of assumptions are not violated. This scenario assumes that, if all relationships defined in the base year are accurate and all other factors are held equal, then the projections embodied in the scenario will come true. That is, if nothing changes and there is no natural regeneration or recovery, harvesting, wood resources will be exhausted. The critical role of these strong assumptions is frequently lost over or completely ignored in the gap analysis. In reality, all other conditions relevant to wood supply are constantly changing, so the scenarios rarely come to pass. The massive forest destruction predicted in the gloomy scenarios has simply not come pass. No rural afforestation campaign can take credit for the survival of national forest resources. Rather, woodfuel resources regenerate well following harvesting and have provided large quantities of woodfuel on a sustainable basis. The HESS report also states "... it is unfair and simply untrue to claim that the continuing pressure to clear forest resources is largely attributed to fuelwood demand." (World Bank/ESMAP and UNDP, 1993)

3.5 Case Study: Cebu, Philippines

Given historical land use patterns in the province, and current farming and tree-planting practices in the uplands, it is apparent that the issue of deforestation and environmental degradation in Cebu is far more complicated than often assumed. The role of woodfuel extraction and use as an agent in this process appears especially prone to misunderstanding. The current extent of deforestation and erosion in the uplands of Cebu appears to be nothing new. The vast majority of the island's rural residents have remained dependent on woodfuels and other biomass fuels for their cooking needs, while the commercial woodfuel trade in the urban areas continues to flourish with prices for these fuels having changed little, in real terms, over the last 20 years. Such evidence suggests that woodfuel extraction may have little to do with deforestation and resource denudation in the past or the present, and that current systems of land use and tree management in non-forested areas of the province may be capable of providing adequate woodfuel supplies for the foreseeable future (Bengal, TG and Remedia, E.M., 1993).

3.6 Land-use Conversion

In Vietnam national data for the period 1980-1990 show that a total of 800,000 ha has been subjected to deforestation whereas agricultural land has increased by 700,000 ha (Ministry of Forestry Vietnam, 1992).

In Sri Lanka between 1956 and 1984 natural forest shrunk by 750,000 ha. In the same period the area used for agricultural production and settlements increased by 833,000 ha (USAID and Natural Resources, Energy and Science Authority of Sri Lanka, 1991).

For Pakistan, the HESS study reports that over a period of one century, 1880-1980, the population has quadrupled. In that period approximately 80,000 km^2 of forest area was converted to other land. Cultivated land increased by 90,000 km^2, and human settlements absorbed another 10,000 km^2. (World Bank/ESMAP and UNDP, 1993).

These country examples strongly suggest that the main reason for deforestation was the conversion of forest land into agricultural land and/or settlement areas and increased woodfuel availability may simply have been an unintended effect of this conversion.

3.7 Quotes

Many institutions and researchers have also published their findings, questioning the fuelwood gap theory. A few are quoted here:

1. "In most countries, forests are disappearing not because people want the trees to burn, but because they want the land under the trees for agriculture."

   (Eckholm, E., Foley, G., Barnard, G., Timberlake, L., 1984)

2. "Forests are predominantly cleared for agricultural land, not directly for energy products."

   (Commission of the European Communities, 1984)

3. "Little attention is paid to changing land-use despite evidence that it is not the demand for fuelwood which creates deforestation but land clearance for agricultural production."

   (Munslow, B., Katerere, Y., Ferf, A., O'Keefe, P., 1988)

4. "To arrest deforestation one needs to halt the depredations caused by agriculture rather than by fuelwood consumption. … Indeed, if all woodfuel use stopped tomorrow, deforestation rates would hardly be altered."

   (Leach, G., Mearns, R.,1988)

5. "Despite a continuing emphasis on the contribution of woodfuel consumption to deforestation, it is becoming increasingly accepted that the primary causes of deforestation are more closely related to land clearance to support agricultural expansion."

   (Dewees, P.A.., 1989)

6. "The bulk of deforestation is due to processes that would proceed at the same pace with or without fuelwood use; and the bulk of the fuelwood in most countries originates from non-forest lands."

   (Veer, C., 1989)

7. "Indeed, in the view of many, population pressure does lead to deforestation, but not because of the direct cutting of wood for fuel. Instead, population growth leads to pressure for more farmland, and natural woodlands are cleared to grow food."

(Hurst, C. and Barnett, A., 1990)

8. "Commercial logging, clearance for large scale ranching, in-migration following road construction or through government-sponsored transmigration schemes, flooding from giant HEP [hydroelectric project] schemes and other development pressure are all widely cited as contributing to large-scale deforestation. The exploitation of forests for fuelwood use contributes little to this process."

(Mercer, D.E. and Soussan, J., 1991)

9. "Rural people rarely fell trees for fuel use, and most depend on trees close to their homes. This means that trees outside the forest, within the agricultural landscape are the main source of fuel for rural people."

(Soussan, J., Mercer, D.E. and O'Keefe, P., 1992)

10. "Indeed, there would be no forest left at all in the Himalayas if some of the predictions made fifteen years ago had been strictly accurate. … There is now ample evidence that many of the early predictions of shortfall were exaggerated, or that local problems were used to suggest national or international disasters in the making."

(WWF, 1992)

11. "Rapid population growth, the need for agricultural expansion, ill-defined or non-existent property rights and distorted economic incentives fuel deforestation in most developing countries."

(Bentley, W.R. and Gowen, M.M., 1994)

12. "All the available evidence shows that the rural fuelwood requirement does not seem to lead to deforestation"

(Ravindranath, N.H. and Hall, D.O., 1995).

13. "... in most cases, fuelwood collection is not a primary cause of deforestation. Furthermore, it is now clear that fuelwood production and harvesting systems can be, and often are, sustainable."

(FAO, 1997a)

Box 1

The Fuel Ladder

A common concept in household energy analysis is the 'fuel ladder'. The concept implies that with socio-economic development, the fuel used by a household will change. To the fuel-users concerned, the top of the ladder looks more attractive, which can mean more convenience, more prestige, greater efficiency, or more of some other preferred quality, as well as a feeling of being more modern. For instance, in South Asia climbing the fuel ladder generally means stepping up from dung cakes to crop residues, wood, kerosene and gas, finally to electricity. In many parts of Southeast Asia charcoal has a very high position on the ladder, perhaps even on the top. Climbing up the fuel ladder also implies climbing up a health ladder, given present technologies for stoves and combustion commonly in use in Asia. Generally, wood does not cause as much smoke as crop residues or dung cakes, and gas and electricity do not cause smoke in the kitchen at all.

Various factors will determine whether or not the household is able to move up its preferred ladder. The main factors are household income and size, availability and costs of the fuel, availability and cost of the required appliances, climate, settlement size and culture and tradition. Further, a variety of user-specific values and judgements often remain implicit. Users make their own choices based on their own perceptions with regard to fuels, stoves, kitchens and related issues.

In the 1980s, it was still believed that energy transitions away from wood and biomass were an option. We now know that that these are not realistic for the larger part of Asia's population. Even climbing up the lower rungs of the fuel ladder is feasible only for some groups. Thus, in the domestic sector, every effort should be made to improve health conditions. This will need policies and interventions co-ordinated among at least the public health sector, extensionists, educationalists and energy technologists.

4. SELECTED WOOD ENERGY DATA

4.1 Energy Balances in RWEDP Member-countries

The annual energy situation of a country is often presented as an energy balance which represents the total energy flow of several energy sources and products from primary production through transformation processes to final consumption, including indigenous production, import and export, transformation and distribution losses and sectoral consumption.

RWEDP recently developed an outline for a wood and biomass energy balance which can be used to present data on wood and biomass energy production, transformation and consumption for a region, country or sub-national area (RWEDP, 1995). It follows the United Nations standard energy balance as far as is possible and convenient, in order to facilitate the integration of the wood/biomass energy balance with existing (national) energy balances.

To get an overview of the use of wood and biomass energy in member countries, RWEDP compiled data from national energy balances and other data sources. The findings are presented in Table 4.1. They show that wood and biomass energy consumption is substantial in all RWEDP member-countries, so these energy sources should be accounted for in national energy balances.

Table 4.1: Consumption of conventional, wood and biomass energy in 1993-94

Unit: PJ	Total Energy	Conventional Energy	Woodfuels	Biomass Energy	Share of Woodfuels in Total	Share of Biomass in Total
Bangladesh	714	210	141	504	20%	71%
Bhutan	14	2	12	12	86%	86%
Cambodia	94	14	79	81	84%	86%
China	31,256	23,866	3,290	7,390	11%	24%
India	8,751	5,822	2,603	2,929	30%	33%
Indonesia	2,796	1,978	818	818	29%	29%
Lao PDR	47	5	42	42	89%	89%
Malaysia	994	898	93	96	9%	10%
Maldives	2	1	1	1	55%	55%
Myanmar	348	77	271	271	78%	78%
Nepal	279	23	192	256	69%	92%
Pakistan	1,984	1,066	521	918	26%	46%
Philippines	965	507	298	458	31%	47%
Sri Lanka	174	79	85	95	49%	55%
Thailand	1,837	1,352	353	485	19%	26%
Vietnam	1,076	260	423	816	39%	76%
RWEDP	51,331	36,159	9,223	15,172	18%	30%
RWEDP without China	20,075	12,293	5,933	7,782	30%	39%
RWEDP without China & India	11,324	6,471	3,330	4,853	29%	43%

Source: Estimated from data of IEA, WRI, Country data and RWEDP's Best Estimates (see Annex 1)

Some general observations on wood and biomass in energy balances are given below:

- Energy balances were only available for Bangladesh, Cambodia, China, India, Indonesia, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam. Of these, nine came from publications of the national energy department, the rest came from publications of international government and non-government organizations;

- For all countries the consumption of biomass fuels is increasing, whereas the share of biomass energy in the total energy consumption is declining for most countries and stable for some;

- Most energy balances group several biomass fuels into one or two categories. Fuelwood is included as a separate column in the energy balances of Bangladesh, Cambodia, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam (without data). UN mentions primary (including fuelwood, bagasse, animal, vegetal and other waste, alcohol and biogas) and derived biomass energy (e.g. charcoal);

- None of the energy balances distinguishes between rural and urban households/areas, and large and small-scale industries. Such a distinction would be relevant for wood & biomass energy since rural households and small-scale industries are generally the main wood and biomass energy consumers;

- The data for the production and conversion of biomass energy for all energy balances are derived from the consumption data using a standard conversion efficiency. This is suggested by the fact that none of the energy balances accounts for distribution losses or statistical differences for biomass fuels;

- The commercial sector is often grouped with the residential sector in most energy balances. Where the two sectors are distinguished the biomass energy consumption of the commercial sector is usually very low. This may be due to a lack of data and the difficulty of distinguishing the consumption of the commercial sector from that of the residential sector rather than the low consumption of biomass fuels as such;

- Data from different sources are rarely consistent, for both conventional and biomass energy.

This overview does not pretend to be complete. There may be other sources of energy data and balances that RWEDP is not aware of, so we would like to encourage national energy agencies and others to provide these data.

4.2 Sources of Woodfuels

The 'gap-theory', often quoted in the past and used to justify action in the field of enhancing forest resources as well as wood energy conservation programmes, was based on the belief that most, if not all, woodfuels originated from forests. The 'gap' between demand and supply was then used to calculate how long it would take before all the forests would disappear due to woodfuel use. However, 10-15 years of in-depth studies have shown that non-forest areas supply considerable amounts of woodfuels. In fact, evidence, albeit sketchy, shows that in many countries a major part, often over 50%, of woodfuels is derived from non-forest areas. The latter include village lands, agricultural land, agricultural crop plantations (rubber, coconut, etc.), homesteads, trees along roads, etc. Table 4.2 gives a brief overview of the sources of woodfuels in some RWEDP member-countries.

Table 4.2: Indicative sources of fuelwood used in various RWEDP member-countries for household(HH) and industrial (Ind.) use as % of total amount used

Country	Year & Sector	million tons	Forest land[1]	Other land[2]	Public land[3]	Unknown
Bangladesh[4]	1981, HH and Ind.	5.5	13	87	-	-
India[5]	1996, HH	162	51	49	-	-
Indonesia[6]	1989, Urban HH	0.5-1.0	6	65	-	29
Nepal[7]	1995/96, HH	6.9	73	27	-	-
Pakistan[8]	1991, HH	29.4	12.6	84.1	-	3.3
Philippines[9]	1989, HH	18.3	13.7	86.3	-	-
Sri Lanka[10]	1993, HH and Ind.	9.2	11	75	-	14
Thailand[11]	1992, Rural HH	5.74	-	56	37	7

Sources:
1 Forest land includes forest plantations as well
2 Other land is mainly own land, neighbours land, common land
3 Public land may include forest
4 Government of Bangladesh, 1987
5 Ministry of Environment & Forests, 1996
6 World Bank/ESMAP, 1990
7 WECS, 1997
8 World Bank/ESMAP and UNDP, 1991
9 World Bank/ESMAP, 1991
10 Ministry of Agriculture, Lands and Forestry, 1995
11 RFD, 1993

4.3 Woodfuels and Employment

Although a large proportion of the woodfuels are gathered by the users themselves, the woodfuel trade is also important, particularly for urban areas and for industrial consumption.

The figures given in Table 4.3 for the woodfuels are probably based on large(r) scale operations only -- evidence from rapid rural appraisals suggests that small scale producers in rural areas collect 20-80 kg. per day. Transporting and retailing this amount may take another day depending on area, means of transport and distance to the market. Using these average figures for small scale rural producers, the employment figure for woodfuels is probably 10 times higher than shown in Table 4.3.

Table 4.3: Estimated employment by fuel type

Fuel type	Amount of fuel per Terajoule (TJ)	Estimated Employment per TJ Energy consumed in Person Days[1]
Kerosene[2]	29 Kilolitre	10
LPG[2]	22 Tons	10-20
Coal[3]	43 Tons	20-40
Electricity[4]	228 MWh	80-110
Fuelwood[5]	62 Tons	110-170
Charcoal[5]	33 Tons	200-350

Source: World Bank/ESMAP,. 1991

notes:

1 *Where applicable, employment covers growing, extraction, production, transmission, maintenance, distribution and sales, including reading meters. It excludes employment generated outside the country for fuels that are imported in semi-finished or finished state.*

2 *This assumes that crude oil (for refining), kerosene and LPG are imported.*

3 *Varying according to capital intensity of the mine, seam thickness, energy value of the coal as well as the distance from demand centres.*

4 *Varies according to production method ranging from hydro to traditional oil/coal fired units and the efficiency of electricity generation, transmission and distribution.*

5 *Depending on the productivity of the site, efficiency of producers and distance from the market.*

4.4 Woodfuel Use and Value of Woodfuels

Although the domestic sector accounts for the lion's share of woodfuel use in most countries, many other users such as industries are also dependent on woodfuels. Much of this use is in the informal sector for which very little information is available and for that reason the industrial consumption is in many cases under-reported. Experience has shown that in most developing countries the industrial sector accounts for 10-30% of all woodfuel use. Table 4.4, however, indicates that industrial fuelwood use would account for only approximately 3% of all woodfuel use. The same statement of under-reporting may be true to a certain extent for the domestic sector, as woodfuel consumption is often based on estimates of average per capita consumption figures. Table 4.4, which shows fuelwood and charcoal use in the domestic and industrial sectors, has been drawn up on the basis of data contained in national energy balances as published by the member-countries, as well as on the basis of additional sources of information.

Table 4.4 gives an indication of the amounts used in the domestic and industrial sectors expressed in '000 tons of oil equivalent or ktoe (1,000 ton oil equivalent, or 1 ktoe equals about 2,766 tons of wood or about 4,600 cubic metres of wood at 600 kg per cubic metre).

The value of woodfuels consumed has been estimated by using average calorific values of woodfuels as well as fuelwood and charcoal prices from FAO forestry statistics. This calculation shows that the estimated value of the recorded woodfuel use in the 15 RWEDP member-countries reaches a staggering 29 billion US dollars per year. This value is expected to be even larger due to under-reporting of woodfuel use in many countries. Furthermore, the result does not account for the social value of fuelwood supply activities.

Table 4.4: Energy consumption in RWEDP member-countries calculated in Petajoules (PJ) from information contained in National Energy Balances etc.

Country	Fuelwood Domestic	Fuelwood Industrial	Fuelwood Total	Charcoal Domestic	Charcoal Industrial	Charcoal Total	Year
Bangladesh[1]	95.76	18.93	114.69	-	-	-	1989/90
Bhutan[2]	12.25	0.99	13.80	-	0.37	0.37	1988/89
China[3]	3,495.00	-	3,495.00	-	-	-	1990
India[4]	3,165.00	240	3,405.00	-	-	-	1991
Indonesia[5]	868.76	-	868.76	-	-	-	1992
Laos[6]	32.83	-	32.83	-	-	-	1990
Malaysia[7]	11.79	-	11.79	5.69	-	5.69	1992
Maldives[8]	1.05	-	1.05	-	-	-	1987
Myanmar[9]	342.87	-	342.87	24.65	-	24.65	1990
Nepal[10]	169.30	6.43	175.73	-	-	-	1994/95
Pakistan[11]	493.85	-	493.85	-	-	-	1993/94
Philippines[12]	231.74	-	231.74	56.98	-	56.98	1992
Sri Lanka[13]	136.12	-	136.12	-	-	-	1992
Thailand[14]	161.93	-	161.93	185.01	-	185.01	1994
Vietnam[15]	395.54	-	395.54	15.44	0.08	16.10	1990
RWEDP	9,613.78	266.35	9,939.75	287.76	0.45	289.33	
% of total	93.98	2.60	97.17	2.81	0.00	2.83	

[1] Habib, A., 1994; [2] Ministry of Agriculture, 1991; [3] ESCAP, 1991; [4] Ravindranath and Hall, 1995; [5] AEEMTRC, 1994; [6] REDP, 1989a; [7] AEEMTRC, 1994; [8] REDP, 1989b; [9] World Bank, 1991; [10] WECS, 1996c; [11] Asian Energy News, 1995; [12] AEEMTRC, 1994; [13] Ministry of Power and Energy, 1995; [14] DEDP, 1995; [15] World Bank/ESMAP, 1994

In order to put the value of woodfuels in perspective, various comparisons can be made. One example is a comparison between the estimated woodfuel value and the value of energy imports. In the case of Thailand, where woodfuels account for less than 30% of all energy use, the value of woodfuels is estimated to be about 2 billion US dollars which is more than 50% of the 1994 energy import bill of 95.5 billion baht (about 3.8 billion US dollars). If woodfuels were to be substituted by kerosene in Thailand the import bill would rise considerably. Using average data for stove efficiencies, heating values and oil prices, it can be shown that the energy import bill of Thailand would rise by about 850 million US dollars. Even though this amount is high, it is considerably lower than the woodfuel value. The difference is caused by the better end-use efficiency of kerosene stoves.

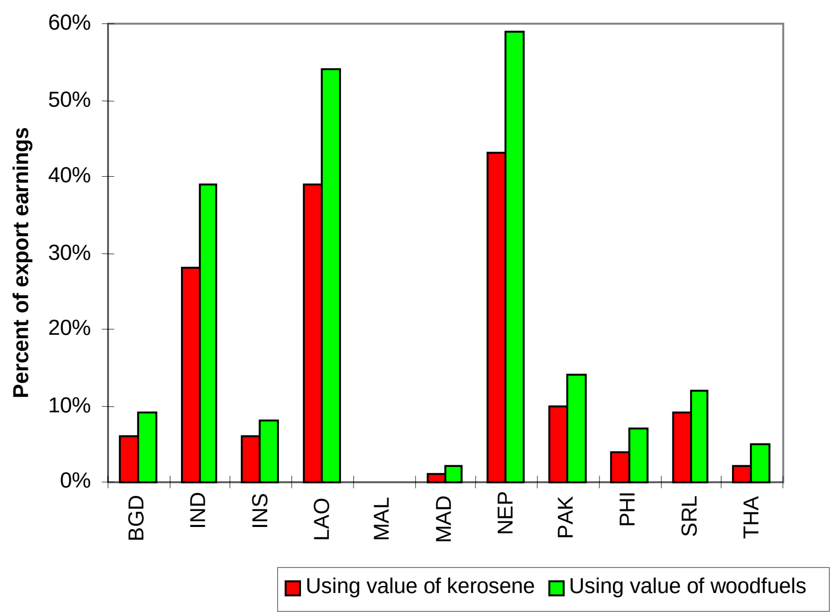
Comparing the value of woodfuel with the export earnings in each country in the same period is also instructive. An overview is shown in Table 4.5 and Figure 2. More recent figures are not yet available, but they are likely to lead to the same conclusions. For those countries where woodfuels are an important source of energy, it is clear that substituting woodfuels by kerosene would be difficult if not impossible, as a large part of their export earnings would be required to pay for the import of kerosene.

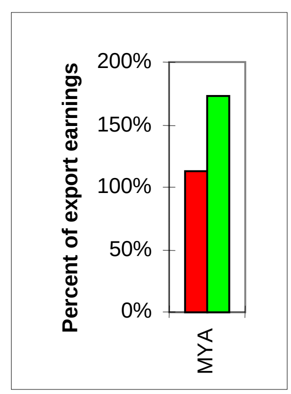
Table 4.5: Woodfuel values in million US$ using average woodfuel prices (1990)

Country	Fuelwood	Charcoal	Dom. FW	Dom. Char	Ind. FW	Ind. Char	Total
Bangladesh	306	-	255	-	50	-	306
Bhutan	37	3	33	-	3	3	40
China	9,320	-	9,320	-	-	-	9,320
India	9,080	-	8,440	-	640	-	9,080
Indonesia	2,317	-	2,317	-	-	-	2,317
Laos	88	-	88	-	-	-	88
Malaysia	31	49	31	49	-	-	80
Maldives	3	-	3	-	-	-	3
Myanmar	914	213	914	213	-	-	1,127
Nepal	469	-	451	-	17	-	469
Pakistan	1,318	-	1,317	-	-	-	1,318
Philippines	618	491	618	491	-	-	1,109
Sri Lanka	436	5	363	-	-	-	440
Thailand	432	1,595	432	1,595	-	-	2,027
Vietnam	1,139	139	1,055	133	-	1	1,278
RWEDP	26,506	2,494	25,637	2,481	710	4	29,000

Note: Assumed fuel prices are 40 US$/Ton or 2.67 US$/GJ for fuelwood and 250 US$/Ton or 8.62 US$/GJ for charcoal. The calorific values assumed are 15 GJ/ton for fuelwood and 29 GJ/ton for charcoal. End use efficiencies assumed are 20% for a fuelwood stove and 30% for a charcoal stove.

Figure 2: Value of woodfuels as % of 1990 export earnings





4.5 Share of Woodfuel in Total Roundwood Production

The data for the total roundwood and woodfuel production in 1995, shown in table 4.6 and Figure 3, are derived from the FAOSTAT data base. This shows an extremely high proportion of woodfuel in total roundwood production in the fifteen member-countries of RWEDP in Asia. Their combined roundwood production in 1995 was about 1075 million m^3, out of which about 865 million m^3 (or 80%) was accounted for by woodfuel. Although China and Thailand also imported roundwood, approximately 6.5 and 2.0 million m^3 respectively, followed by India and Philippines (both less than 1.0 million m^3) others did not import at all. This high share of woodfuel in total roundwood production is a clear manifestation of their heavy reliance on fuelwood and charcoal for energy. The share of fuelwood and charcoal (woodfuel) in total roundwood production is low (22%) only in Malaysia, which is at par with the most developed countries in Europe. In all other countries its share is 68% (China) or more, and is as high as 98% in Bangladesh. For comparison, the share of fuelwood and charcoal in total roundwood production in North and Central America, South America, Europe and Asia comprise 21%, 67%, 16% and 76% respectively.

RAP publication no. 1995/22, "Selected Indicators of Food and Agriculture Development in Asia-Pacific Region, 1984-94", published by FAO, Bangkok does not show a decline in the average annual growth rate of fuelwood and charcoal production in any of the RWEDP member-countries (FAO, 1995a). As a matter of fact, it is still growing everywhere, averaging between 1.9% and 1.4% in rapidly industrialising countries like Indonesia and Thailand, and at a growth rate not less than 2%, annually in others. On the other hand, industrial roundwood production in Bangladesh, Bhutan, Philippines, Sri Lanka and Thailand has declined at an average annual growth rate of -4.5%, -8.1%, -6.2%, -0.5% and -5.5% respectively, between 1983 and 1993.

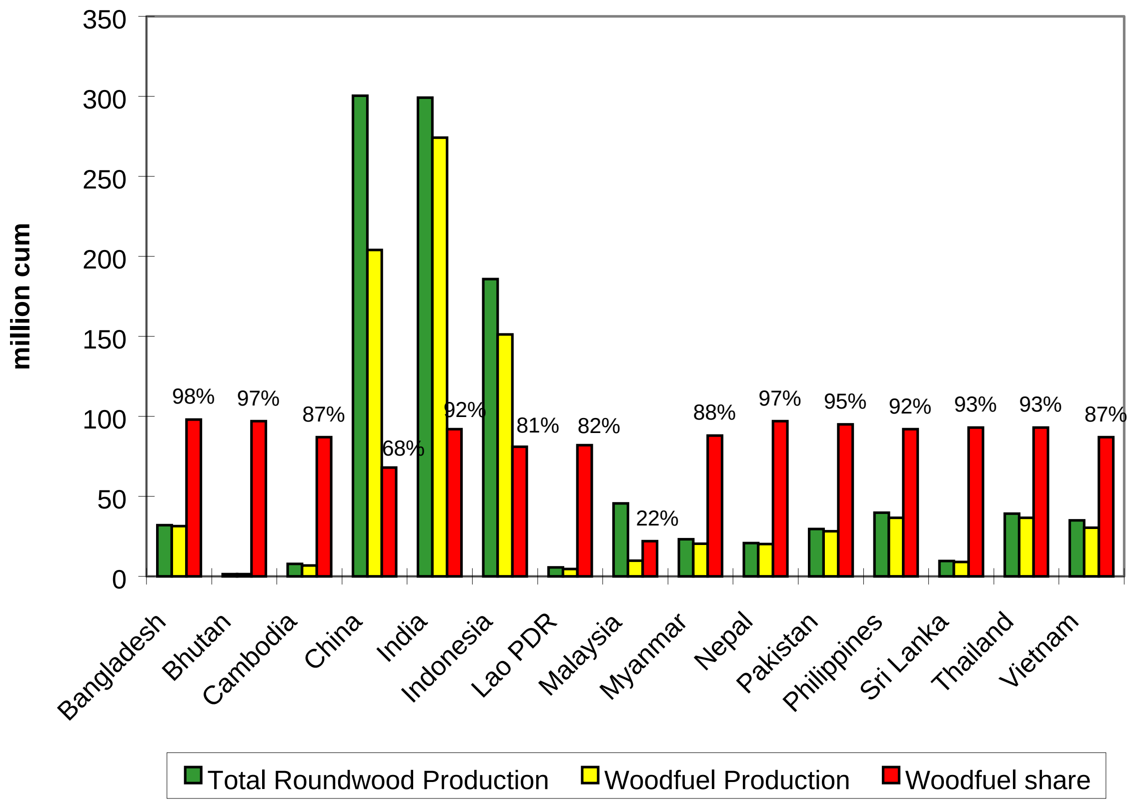
Table 4.6: Forest and plantation area, roundwood and woodfuel production in 16 RWEDP member-countries

	Total Land *(1000 ha)*	**Total** *(1000 ha)*	**Natural** *(1000 ha)*	**Plantation** *(1000 ha)*	**Roundwood** *(1000 CUM)*	**Woodfuel** *(1000 CUM)*	**Share of Woodfuel in** *(%)*
Bangladesh	13,017	1,010	700	310	32,044	31,310	98
Bhutan	4,700	2,756	2,748	8	1,399	1,354	97
Cambodia	17,652	9,830	9,823	7	7,765	6,725	87
China	932,641	133,323	99,523	33,800	300,360	204,059	68
India	297,319	65,005	50,385	14,620	299,163	274,272	92
Indonesia	181,157	109,791	103,666	6,125	185,895	151,228	81
Lao PDR	23,080	12,435	12,431	4	5,508	4,511	
Malaysia	32,855	15,471	15,371	100	45,573	9,819	22
Maldives	30	-	-	-	-	-	82
Myanmar	65,755	27,151	26,875	276	23,281	20,450	88
Nepal	14,300	4,822	4,766	56	20,822	20,202	97
Pakistan	77,088	1,748	1,580	168	29,665	28,116	95
Philippines	29,817	6,766	6,563	203	39,857	36,540	92
Sri Lanka	6,463	1,796	1,657	139	9,625	8,925	93
Thailand	51,089	11,630	11,101	529	39,288	36,502	93
Vietnam	32,549	9,117	7,647	1,470	34,913	30,470	87
Total	1,779,512	412,651	354,836	57,815	1,075,157	864,483	80

Source: Area data from FAO, State of the World's Forests 1997; Production data from FAO Forestry Data Base

It has increased significantly in Lao PDR and Pakistan by 8.8% and 11.9% respectively. In Indonesia and Malaysia it has increased moderately, 3.9% and 4.1% respectively, and in the remaining countries the growth has been only marginal, from 0.7% to less than 3%. Although most countries in the region have been progressing rapidly in terms of their economic growth in recent years, their use of fuelwood and charcoal for energy has not declined in absolute terms over the years. The domestic sector is the greatest user of wood energy for cooking, space heating and agro-processing, primarily in rural areas. Infrastructure, availability and affordability of substitute fuels, local social cultural practices, income and living standards of users, government policy related to energy, etc. all, seem to play an important role in the selection of fuel by households for meeting their basic energy needs.

Figure 3: Share of woodfuel in total wood production, 1995



4.6 Forest and Wood Processing Residues

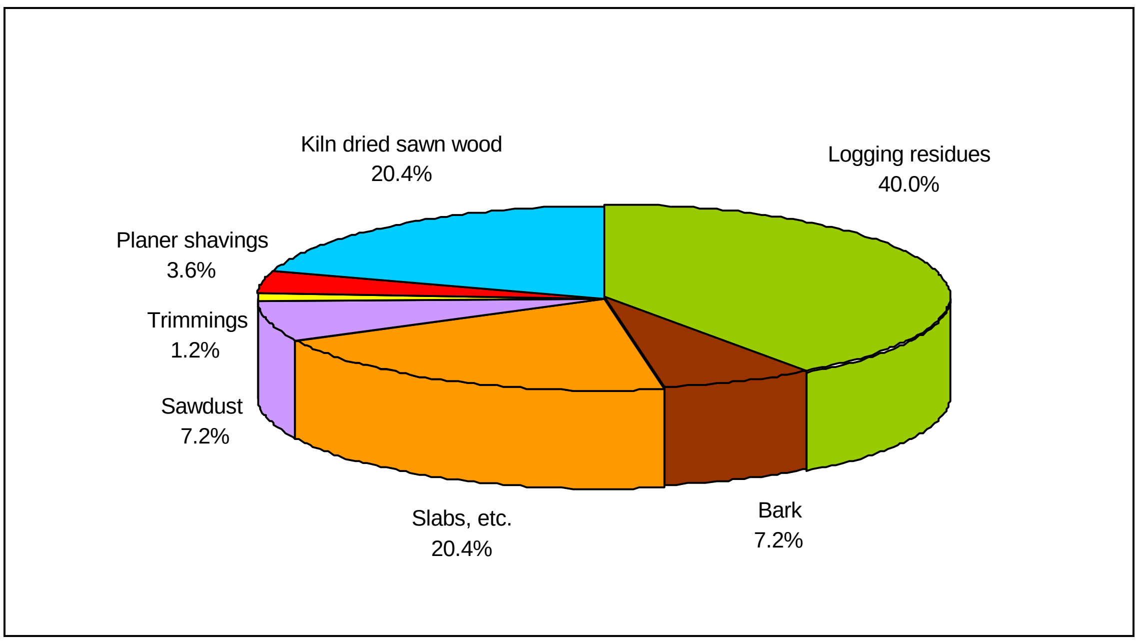
Sawn wood is normally produced from logs. However, the process of conversion from trees in the forest to logs and subsequently to sawnwood is associated with waste. This waste can be in various forms such as logging waste (branches, stumps, etc.) as well as other processing waste. The following provides a brief overview of the amounts of waste generated from trees in the forest to kiln-dried sawn wood ready to be used. It should be noted that average figures are shown here and that variations in the amount of wastes generated are common, depending on methods used, etc.

When cutting trees in the forests, recovery rates vary considerable depending on local conditions. A 50/50 ratio is often found in the literature i.e. for every cubic metre of log removed, a cubic metre of waste remains in the forest (including the less commercial species). Where logging is carried out for export purposes, values of up to 2 cubic metres of residues for every cubic metre of log extracted may be valid (Adams, M., 1995). Other sources (Government of Indonesia, 1990) give a ratio of 60/40 i.e. 6 cubic metres of logs versus 4 cubic meters of waste remaining in the forests. The 40% consists of: 12% stemwood (above first branch), 13.4% branch wood, 9.4% natural defects, 1.8% stemwood below first branching, 1.3% felling damage, 1.6% stump wood and 0.5% other losses. Figures of 30% logging wastes have been reported from Malaysia (FRIM, 1992) but others (Jalaluddin et al, 1984) indicate a recovery rate of 66% with 34% being residues consisting of stumps, branches, leaves, defect logs, offsets and sawdust. This figure may be higher if unwanted species intentionally or accidentally felled are considered as well. Most of the wood residues are left in the forest to rot, particularly in sparsely populated areas where the demand for woodfuels is low.

Once the log has been produced, it is transported out of the forest for further processing such as in a saw mill where it is converted into sawn wood. Recovery rates vary again with local practices as well as species (FE, 1990). After receiving the logs, about 12% goes to waste in the form of bark. Slabs, edgings and trimmings amount to about 34% while sawdust constitutes another 12% of the log input. After kiln drying the wood, further processing may take place resulting in another 8% waste (of log input) in the form of sawdust and trim end (2%) and planer shavings (6%).

In brief, as is shown in Figure 4, an estimated 80% of the trees in the forest goes to waste while only about 20% of the original tree in the forest ends up in the form of kiln dried sawn wood.

Figure 4: From standing tree to kiln-dried sawn wood



4.7 Agro-residues as a Source of Energy

Every year large quantities of ago-residues are generated, which are an important source of energy for domestic and industrial purposes, e.g. between 10% and 50% of all rural energy. The use of residues as a fuel puts pressure on the resource base. In order to judge the impact of increased use, an overview of the potential supply and demand should be prepared. A distinction should be made with regard to location. Ago-residues are generated either in the field where the crops are grown (straw and stalks) or at processing centres (husks of grain, shells, etc.). The field-based residues are difficult to collect and therefore often left to be burnt where they are. The process-based residues are used more extensively as a source of energy.

Agro-residues are used for many purposes, notably, the ‘six F's’: Fuel, Fodder, Fertiliser, Fibre, Feedstock and Further uses. The last F comprises for instance soil conditioning (coconut coir dust to retain moisture in the soil), use as a growing medium (straw for mushroom, coconut husks for orchids), packing materials, etc. Residues may even have multi-purpose uses: rice husk can be burnt as Fuel and the ash used by the steel industry as a source of carbon and as an insulator (Feedstock/Further); rice straw can be used as animal bedding (Fibre or Further) and subsequently as part of compost (Fertiliser); crop waste can be used as a Feedstock for biogas generation (Fuel) and the sludge as Fertiliser, etc.

It is unwise to assume that residues are wastes and therefore by definition more or less ‘free’. Even where residues are at present freely available, they are likely, sooner rather than later, to acquire a monetary value. For instance:

- About 15 years ago rice mill owners in Indonesia gave away rice husks free of charge to truck drivers and brick makers, and would even provide free labour to load it. Once a market had developed brick makers had to pay for the husks and for labour to load the husks.

- The increased use of rice husk as a boiler fuel in the Nepali carpet industry resulted in a tenfold increase in the price from 2 to 20 NRs (about 0.04–0.40 US$) per bag of 20 kg over a period of only 14 months.

The wastes may also be used for various purposes in the local community without direct monetary value. Such situations are not always apparent to an outsider. In common share-cropping systems the crop as well as the residues are divided between the landowner and the tiller. Also, landless people have access to residues on common lands, and sometimes may collect residues from other peoples' lands. Trying to use these residues without compensation is likely to create problems. Even in cases where money changes hands, payments may be made to some other person than to whom the original benefit accrued, which may lead to social disruptions in the community. Further factors to be considered in addition to competing use are: seasonality with large quantities available immediately after the harvest; ownership and access; fraction which can be recovered economically or in terms of the environment.

In order to estimate the amount of residues generated, use is often made of ‘Residue to Crop-production’ (RCR) or ‘Residue to Area-planted’ (RAR) ratios. Both ratios can be applied for both field and process-based residues, but RCR is most commonly used for statistical purposes because it is often more reliable than RAR (due to multiple crops per year, intercropping, etc.). However, RCR values can vary to a great extent (possibly even from year to year) depending on several factors, like variations in weather conditions, crop variety, water availability, soil fertility, farming practices, etc. Although for most crops general RCR data are available, in many cases the moisture content of residues is not given. This makes calculating the amount of residues based on crop production tricky. The following example demonstrates the risks of using RCR:

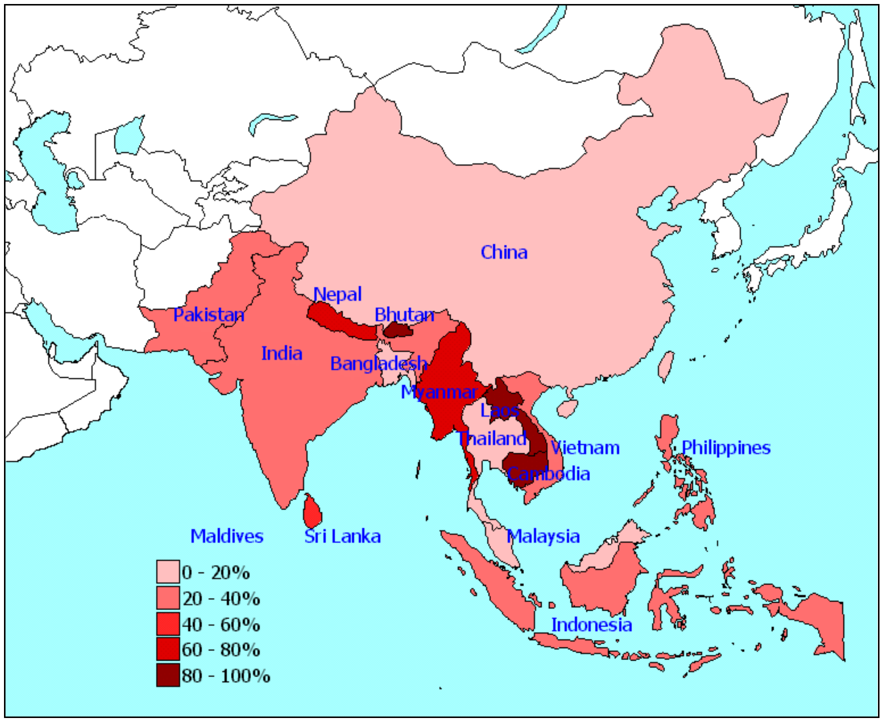
Rice straw: RCR's in the range of 0.416 to 3.96 have been cited in various references. The lowest amongst the values, 0.416 reported by AIT and EEC (1983), and 0.452 by Bhattacharya, S.C. and Shresta, R.M. (1990), are based on the practice of harvesting rice in parts of Thailand and other Southeast Asian countries where only the top portion of the rice stem along with 3-5 leaves is cut, leaving the remainder in the field. Where the rice is cut at about 2" above ground, the RCR becomes 1.757 (m.c. 12.71%) as reported by Bhattacharya, S.C. et al (1990). Vimal, O.P. (1979) indicates an RCR of 1.875 based on Indian experience while in Bangladesh a value of 2.858 has been reported (Government of Bangladesh, 1987) which however may be valid only for a local variety (floating rice).

Data for rice straw as presented in Table 4.7 show large variations. Due care should be taken in using RAR and RCR values to calculate the amount of residues generated in a certain area or period. Field checking should determine the most appropriate value for a given situation.

Table 4.7: Some Residue-to-Crop Ratios for Rice Straw

Reference	RCR	Moisture content (%)	C (%)	N (%)	LHV (MJ/Kg)	Ash (%)
Webb, B., 1979	2.60 – 3.96	10-12				12.7-21.4
Vimal, O.P., 1979	1.88					
AIT and EEC, 19'83	0.42	27			15.10	16.98
Government of Bangladesh 1987	2.86					
Barnard,G., et al., 1985	1.40 – 2.90					
Strehler, A. and Stutzle, W., 19'87	1.40	12-22	41.44	0.67	10.9	17.4
Bhattacharya, S.C., et al., 1990	0.452	12.71	24.79		16.02	21.05
Massaquoi, J.G.M., 1990	1.10 – 3.00					
Ishaque, M. and Chahal, D.S., 1991	1.40					
Ryan, P. and Openshaw, K., 1991	1.10 –2.90					18-19
Kristoferson, L.A. and Bokalders, V., 1991	1.10 –2.90					
Bhattacharya, S.C. et al, 1990	1.757	12.71	39.84		16.02	

5. WOOD ENERGY CONSUMPTION PATTERNS



Share of wood energy in total energy consumption

Some of the fastest growing economies in the world, with some of the greatest increases in commercial energy consumption over the last decade, are found in RWEDP member-countries. These economies are also seeing their consumption of traditional energy, mainly woodfuels, increasing. The rise in woodfuel consumption is projected to continue for some years to come. Hence woodfuels continue to be a significant energy source in these countries and are expected to remain so in the foreseeable future.

5.1 Macro Analysis of Wood Energy Consumption

In a macro or aggregate analysis, the factors considered to be affecting total energy consumption are population, level of economic activity in terms of Gross Domestic Product (GDP), and level of national income in terms of Gross National Product (GNP). Increasing population generally leads to increasing economic activity (thus of GDP). Increases in population and economic activities in a country often lead to increases in consumption of energy. Increasing economic activities lead to increasing incomes and a better quality of life for more people. This generally results in more diverse energy applications and additional energy uses.

Macro analysis of energy consumption of specific energy sources such as wood, oil and electricity considers the same set of factors mentioned above. These factors can have quite different effects on the consumption of each type of fuel. The effects can also be different when compared to the total energy consumption.

An aggregate analysis of wood energy consumption of the region covers the differences that exist among the various countries. Differences in the patterns of current and future consumption of wood energy among countries can be substantial. However there are general trends that can define broad features of the future scenario of wood energy consumption in the region.

5.1.1 Population Trends

RWEDP includes the three most populous countries in the world: China, India and Indonesia. In 1995, these three countries already made up almost 41% of the world's population. If the populations of the other 13 RWEDP member-countries are included, the region's share of the world's total population is 51%. In the last decade, the population growth rate in the region ranged from 1.3 to 3.2, compared to a world average of 1.7. Population growth might have slowed in some member-countries, but this region is forecast to have one of the fastest population growth rates in the world in the coming years.

5.1.2 Economic Growth and Income Patterns

During the last decade, the average economic growth rate in the region, measured in terms of GDP growth rates, ranged from 2.2 to 9.7, as compared with a world average of 2.9. The region, particularly the Southeast Asian countries, has the highest economic growth rates in the world, which has transformed its economies. Industries and services have increased their share in the economy, while agriculture has intensified production. Economic liberalisation and international trade links have tremendously increased, providing further impetus towards achieving greater economic outputs. All these factors point to higher energy consumption by the economies in the region.

Income in the region, measured in terms of GNP growth rates, has risen. GNP growth rates in the last ten years ranged from 3 to 12, higher than the world average of 8.3. However, the average income per capita of US$ 470 is still much lower than the global per capita average of US$ 4260. Nevertheless, the rise in incomes has been dramatic and changes in the quality of life of many people in the region have been significant. Many have moved up the income ladder and with it have adopted lifestyles that require more diverse uses of energy. They have adopted many of the conveniences of modern living, most of which require more energy consumption (such as increased use of motor vehicles and modern electrical appliances). As more people move up the income ladder, more will be adopting energy-intensive lifestyles. This is another reason why energy consumption is set to increase rapidly in the region in the future.

However, the region is also marked by a very skewed pattern of income distribution. A large segment of the population in most countries has yet to benefit from the economic growth and increases in national income. The region is still host to the largest number of people living below the poverty line. UNDP, in its 1997 Human Development Report (UNDP, 1997), reported that South Asia has a higher number of poor people than any other region in the world. This situation seems certain to continue for some time to come, despite current efforts towards poverty alleviation. The incidence of poverty is the most significant parameter that drives significant traditional use of woodfuels and residues. Nevertheless, the impact of poverty is often overlooked in macro analyses of energy consumption.

5.1.3 Total Energy Consumption Trends

In 1994, the total energy consumption of the region was about 50,000 petajoules, equivalent to 21% of the total world energy consumption. Total energy consumption includes both conventional and traditional energy consumption. During the last decade, the total energy consumption growth rates of countries in the region grew higher than the world average. The range of average annual growth rate values were from 1.5 to 8.0 compared to the world average of 1.9. However, energy consumption per person in the region is lower than the world average and still much lower than that of the developed countries. Per capita energy consumption in the region ranges from 1 to 50 gigajoule compared to the world average of 42 gigajoule and to the OECD average of 133 gigajoule. The energy intensity of economies in the region (measured in terms of the ratio of total energy consumed and GDP) ranges from 6 to 70 megajoule per US$.

With the population and economy of the region growing and stimulating the socio-economic transformation that moves societies to more diverse and intensive uses of energy, we can expect the demand for and the consumption of energy to accelerate. As mentioned earlier, more people will move up the income ladder and adopt energy-intensive lifestyles. Given that economic growth rates in the region are higher than the global average, and with a population accounting for more than half of the world's population, the region's energy consumption growth rate is expected to be higher than the world average and the energy use in the region will grow far beyond what it is today.

Several methods are used to project future energy consumption. The simplest approach is to extrapolate energy consumption trends over time, or on the basis of either population or economic growth rates. The results arrived at are usually different. Other methods are available which combine the effects of population and economic growth on energy consumption. However, whichever method is used, all results point to continued significant increases in energy consumption in the countries discussed above.

5.1.4 Wood Energy Consumption Trends

Traditional energy sources include wood and other biomass energy, such as agroresidues and animal dung. In most countries, wood makes up the majority of traditional energy sources. Unfortunately, there is little information specifying the composition of the traditional fuels.

FAO estimates that annual per capita wood energy consumption among RWEDP countries ranges from 150 to 680 kg per person or 2.2 to 10.2 gigajoule per person. Although the values that FAO uses vary from country to country, FAO assumes those country-specific values remain constant over the years. FAO data include both fuelwood and charcoal. It estimates wood energy consumption based on the population (see Annex 2). Using the FAO approach, the total wood energy consumption in the region in 1995 was estimated to be 860 million cubic metres or 8,430 petajoules. This is 45% of the estimated world consumption of wood energy for that year.

What is interesting to see is the share of wood and other traditional energy in total energy consumption. Data shows that consumption of woodfuels is significant but the share has been declining. The share of wood and other traditional fuels ranges from 18 to 91 percent of total national energy consumption. However, a closer look shows that through the years, the absolute values of traditional energy consumption in most member-countries are increasing.

Based on the FAO approach, the projected wood energy consumption in the region by the year 2010 is expected to be 10,200 petajoules or 1050 million cubic metres.

A recent study commissioned by FAO Forestry Department (FAO, 1997b) provides future amounts of wood energy consumption using a mathematical model that accounts for population growth, level of economic activity and changes in the prices of wood products. On the basis of this study, wood energy consumption in the region is projected to be 1000 million cubic metres in the year 2010.

5.1.5 Constraints on Macro Analysis

Macro analysis techniques provide a simple approach to studying energy consumption and projecting future energy consumption. However, such techniques do not account for the many factors that drive energy consumption and the types of fuel used. Thus, macro analysis techniques may not be an accurate tool in terms of projecting trends in consumption of specific fuels such as wood, petroleum or electricity.

Applying only macro-factors such as population or economic growth rate overlooks the other determinants of wood energy consumption. Among the more important determinants are pattern of income distribution, location of users, fuel prices and fuel accessibility. The pattern of income distribution is an important parameter determining consumption of woodfuels. Its effect is completely hidden if extrapolation of total energy consumption based on population, GDP and GNP are the only techniques used to analyse consumption. In the past, macro analysis usually led to energy programs that neglected wood and other traditional energy, specially those for low-income users.

The results of macro analyses however are useful for defining broad policy measures for wood energy development and also for defining further specific data collection activities. However, for formulating specific strategies which entail detailed programming, designing projects, and making decisions for investments, more detailed analyses are needed.

5.2 Sectoral Analysis of Wood Energy Consumption

Sectoral analysis or the analysis of the energy consumption of each economic sector provides a more grounded approach in understanding energy-economy interactions. It thus provides a better basis for projecting future energy consumption. It can be the basis for fine tuning policies that include well-focused intervention programs and appropriately designed investment projects.

A sectoral energy analysis usually divides the economy into five major categories or sectors: household, industry, agriculture, service and transport. Wood energy is relevant in all sectors except transport. Each sector is treated as having some unique characteristics and patterns of energy consumption, including unique patterns of wood energy consumption.

Sectoral energy analysis accounts for changes in the economic structure of a country due to changes in the share of the contribution of each sector. It can also account for changes in specific energy consumption in each sector, and thus, recognises that the specific energy consumption of the total economy is not constant but changes over time. Finally, it can also account for changes in the specific energy consumption for each type of fuel such as wood, kerosene, gas, and electricity over time. These changes are very pronounced particularly during periods of rapid economic growth and transformation, which is what most of the RWEDP member-countries have been experiencing in the last ten years.

Most RWEDP countries have conducted sectoral energy consumption analyses but most are focused on projecting future consumption for commercial energy sources and electricity. There are few countries which have studied the future consumption of wood and other traditional fuels using the sectoral analysis approach and these have been mostly household sectoral studies.

Generally, the household sector is the greatest consumer of wood energy. Households use it mostly for cooking, which in many countries is a major energy application. Significant use of wood energy also occurs in industries, particularly in traditional, mainly rural, small-scale industries. Also, the amount of wood energy used to generate process heat and electricity for modern industries is increasing. The service sector is another important user of wood energy, as it is used in large and small-scale cooking, e.g. by ambulant food vendors, cafes, restaurants and hotels, and also by public and private institutions such as schools and hospitals. A sectoral analysis of wood energy consumption involves closer investigation of each of these sectors to identify and annualise the factors that influence their present and future consumption of wood energy.

5.3 Wood Energy Consumption in the Household Sector

The primary factors driving total energy consumption in the household sector are population size and levels of household income. The agro-ecological situation also influences the total energy consumption of the sector, as do socio-cultural factors, but these determine why energy consumption differs from place to place. For example, households in temperate regions use more wood for cooking and space heating.

The patterns of household energy consumption or the differences in levels of household energy consumption are determined by patterns of household size and income, types of energy application, efficiencies of wood energy devices and households' accessibility to fuels. To provide indicators of fuel accessibility, the following parameters are usually used: location of households – whether urban or rural; prices of fuels and, particularly for woodfuels and agricultural residues, the time taken to collect these fuels. It is the combination of all these factors that determines the amount of wood energy consumed in the household sector.

At present, the majority of households in most of the RWEDP countries gather their fuelwood "for free". These are mostly the low-income households located in rural areas involved in agricultural production activities. In analysing wood energy consumption, there is a need to differentiate between use of fuelwood by rural people who gather mostly twigs and branches for their daily fuel needs and those users who purchase their woodfuels, for example, in urban areas. However, "free" fuelwood gathering also occurs in urban areas, among poor families who gather their wood from dumpsites, construction sites and even from trees planted along roadsides and rivers.

5.4 Consumption in Fuelwood-gathering Households

Though consumption by fuelwood-gathering households (or households using "non-traded fuelwood") is significant in member-countries, exact figures are not known for many countries. Data from Pakistan (World Bank/ESMAP and UNDP, 1993) showed that around 60% of woodfuels used in the country are gathered while data from the Philippines (World Bank/ESMAP, 1991) gave an estimate of about 78% for that country. It must be noted that in both countries, there are households which both gather and buy the wood they use.

What, however, is indisputable is that in most countries "non-traded woodfuels" is the main source of fuel for cooking in low- income rural households. It is also used for water heating and, in temperate regions, for space heating. These are the main types of applications for non-traded fuelwood.

Rural people, who mostly use non-traded woodfuel, generally use more woodfuels for cooking than their urban counterparts, because end-uses are generally less efficient. Stoves used in rural areas, mostly self-made by women, require no financial expenditure, and are generally inefficient. Since, woodfuels are generally gathered "for free", this further discourages efforts towards more efficient use.

Besides the level of efficiency of wood energy devices, other specific factors that influence consumption of non-traded fuelwood in the household sector are population size, income levels, and fuel accessibility. Increasing population generally means increasing wood energy consumption by low-income households. Increasing income and fuel accessibility encourages a shift away from woodfuel use. However, these factors can produce very different sets of impacts in different situations.

5.4.1 Effects of Population Size

An increase in population without attendant changes in the patterns of household income or, more specifically, without significant increase in the number of households moving up to higher income levels leads to increasing use of non-traded fuelwood. How much woodfuel is consumed depends upon the number of households that falls below a threshold income level below which, households cannot afford to buy traded fuels, including traded fuelwood and charcoal. Thus, these households gather their own fuel. The larger the number of households falling under this threshold income level, the larger will be the total consumption of non-traded fuelwood in the household sector.

5.4.2 Effects of Income Levels

The threshold income level varies from country to country and even within regions there is a range of values. This range is determined not by cash income earnings but by real income earnings, which include income in kind earned by the family. Income in kind is common in rural households, examples of which are consumption of their own agricultural produce and available free time to gather fuelwood. Use of fuelwood in the household sector may decline even if population increases if there is a significant number of households moving up beyond the threshold income level.

In many places, the threshold income level may be way above the official poverty line. Thus, many households classified as living above the poverty line still cannot afford to buy fuel, even woodfuel, and instead have to gather it.

Low household incomes can affect fuelwood consumption in other ways too. Many poor rural households find lower grade fuels such as agriwastes and dung important alternatives to fuelwood. Even if they have access to fuelwood, rural users may use the lower grade fuels instead of fuelwood and then *sell* the fuelwood for additional income. The impact will be very difficult to predict. Woodfuel consumption could either increase or decrease, depending on how many poor households shift to agriwastes and how many more households use the fuelwood sold by the former. It is also very possible that buyers of the woodfuels are non-household users such as food vendors, eateries and even industries. The only thing that seems to be definite here is that there will be more users of traditional energy such as woodfuels and residues. This is an example of the intricate link between traded and non-traded woodfuel which complicates any attempts to analyse the future demand for fuelwood.

5.4.3 Access Constraints

Access to fuelwood resources is another factor determining the amount of non-traded fuelwood consumed by households. Access to woodfuels means having physical access to the source, the right to gather woodfuels from that source and having the necessary field labour available to collect and transport it. Such field labour is usually supplied by women and children.

Access to fuelwood affects level of consumption as it can restrict supply and force fuelwood users to shift to alternatives - usually lower grade fuels. Access to fuelwood can be restricted because of limitations imposed by the location of the resources in relation to consumption, by land tenure and ownership of biomass resources and, finally, by the way in which biomass resources are managed. Whether people are willing to make the extra efforts needed to overcome these constraints depends on the available alternatives to wood, their income level and the income opportunities for wood collectors.

5.4.4 Prospects for Fuelwood-gathering Households

Significant use of non-traded woodfuels appears certain to continue for the foreseeable future, because of two factors. Firstly, most countries will continue to have large percentages of their population remaining poor. In spite of projections for these countries of higher economic growth rates and even a current decline in the number of people living below the poverty line, the absolute number of poor households will still remain significant. Thus, many households will continue to live below the threshold income level and will not be able to afford to buy traded fuels, including fuelwood. These households will gather fuelwood for their own use or they may use residues and sell the fuelwood for income.

The second factor that will keep on encouraging fuel gathering activities by households is the continuing availability of “free” labour, mainly provided by women and children, to collect the fuelwood needed by these households. Even if woodfuel-collecting trips were long or becoming longer, it would probably not be a matter of concern, particularly to men. Only if labour becomes scarce will the collection of even abundant woodfuel supplies be perceived as a serious problem, and the users may move to lower grade fuels. A more desirable development is to provide opportunities to both men and women to raise their incomes. This would allow them to send their children to school and to buy the fuel they need. But apparently this scenario is not considered realistic in many countries.

On the other hand, the factors that could restrain used of non-traded fuelwood are non-physical access factors, such as tenural and legal rights. However, it is very possible that collection and use of fuelwood will continue even if such access restrictions are present. Poaching will always be resorted to, especially if lower quality fuels such as shrubs, dung cake and crop residues are not accessible to poor households.

In the absence of more detailed data, values for the key factors that determine continued fuelwood gathering activities in households are difficult to obtain. These key factors, as mentioned above, include “real” family income; available free time of collectors – particularly of women and children; access constraints to wood resources and accessibility to alternative fuels. These are site-specific parameters that need site-specific wood energy surveys. The lack of detailed data makes it difficult to do accurate projections of wood energy consumption which take account of the previously mentioned factors.

Generalising values for these parameters in order to do national-level studies may be lead to erroneous results because first, there are difficulties in defining general quantitative indicators for these parameters, and second, there are large variations in the factors from place to place, particularly in large non-homogenous countries. This is one of the reasons why wood energy analysis and planning needs to be conducted using a decentralised area-based approach. This would enable the specific characteristics of the present situation and future trends to be analysed, but more importantly, it would allow the design of site-specific strategies and programs to address wood energy development issues. On the basis of these various decentralised area-based analyses and plans aggregate values of present and future consumption trends can then be extrapolated and used for the validation of overall broad national policy measures.[1]

5.5 Consumption of Traded Woodfuels

Trading of fuelwood and charcoal is mostly found in urban areas. In these places, the majority of the users are poor households. Fuelwood and charcoal are mainly used for cooking. They are also use for space heating and, particularly in the case of charcoal, for ironing clothes. However, in both urban and rural areas, there are also higher income households which buy and use fuelwood and charcoal. Some may have the money to buy conventional fuels such as kerosene and LPG but have difficulty obtaining them. Others may want to use fuelwood and charcoal as secondary fuels or as fuels to cook special dishes. Many types of establishments also buy woodfuels for commercial and industrial applications, mainly to generate process heat or steam.

5.5.1 Household Consumption Patterns

While it is mainly income levels and the price of fuels that determines the pattern of consumption of traded fuels in urban households, for rural households, security of supply of modern fuels is another additional factor that has to be considered, though this may also be true in many smaller urban areas.

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1 As mentioned earlier, tentative or initial overall broad wood energy policies and strategies may be defined using macro analysis techniques.

Among households purchasing woodfuels, increasing household incomes generally lead to a decrease in the number of woodfuels purchased and in total woodfuel consumption. Households purchasing woodfuels are more sensitive to relative prices and inter-fuel substitution when their income changes. There are opportunities for woodfuel savings by introducing improved stoves which could be commercialised through wood traders. There are also opportunities for fuel switching.

5.5.2 Impacts of Urbanisation

Large cities generally have higher household incomes and a better supply of modern fuels such as kerosene, LPG or even piped gas. As urbanisation increases, firewood consumption in urban households appears to decrease. Comparative studies of urban areas show that the population size of a city is strongly correlated with the proportion of households using fuelwood and their level of consumption. The number of households which use fuelwood in large cities is much lower than in smaller cities. Urbanisation is an indicator both of greater accessibility to modern fuels and of higher household income levels.

As countries in the region develop, more areas are becoming urbanised and more people are living in cities. More families have higher incomes now than previously and this change is expected to continue in the future. Better infrastructure is being developed to supply modern fuels. It is thus expected that these factors will contribute to the decline in the consumption of "traded" woodfuels in the future. Many households purchasing woodfuels in both urban and rural areas will shift away from woodfuels when they can afford conventional fuels and when the supply of conventional fuels is secured.

However, urbanisation has also brought with it changes that could also mean increased use of woodfuels, or at least continued use at present levels. The following observations seem to indicate this. However, these observations need further investigation to validate them and the conclusions that are tentatively drawn from them.

5.5.3 Urban Poverty and Woodfuel Consumption

Though average urban income levels in most countries have been steadily rising for some years, like any macro-indicators, they do not show how unevenly income is distributed or that a large number of people live in poverty. Most of these low-income people use woodfuels. They cannot shift to modern fuels because they cannot afford to buy a modern cookstove. It is quite likely that although some of these people could afford to buy modern fuels and a modern cookstove they find fuelwood and charcoal cheaper than kerosene or LPG, so they continue to use their wood stove to save on the cost of cooking their meals. Most of these households are found in slum colonies and marginalised areas in many large cities of the region.

Evidence indicates that the population in these slum and marginalised communities is growing due to the influx of poor families from rural areas attracted by the opportunities that the cities offer them. As mentioned before, some of them are so poor that they resort to fuelwood gathering even in the cities. With these people continuing to live in marginalised conditions the use of "traded woodfuels" will continue. If the urban poor population continues to grow an increase in the consumption of traded woodfuels is likely to be a consequence.

5.5.4 Impacts of Changing Social Norms

Urbanisation has also affected social structures in a way that has altered how families prepare and eat their meals. Both the husband and wife now work in an increasing number of urban families and many of these families live in a nuclear family arrangement rather than in the traditional extended family which could have provided support for household and family maintenance. With many of these nuclear families finding hired household help, e.g. a cook, to be too much of a financial burden eating outside and buying cooked food from the ubiquitous food vendors and eateries found in many Asian cities is an increasingly popular alternative to them. Interestingly, it seems that many of these food vendors and eateries use fuelwood and charcoal to cook the food they serve.

No systematic studies have been carried out yet to estimate the amount of woodfuels used by commercial food establishments and correlate it with the amount of energy used for cooking by urban households. However, some household energy surveys have shown that urban households which mostly eat outside or buy their food already cooked have significantly lower energy consumption. While household energy consumption for cooking is decreasing energy consumption of the service sector, particularly that of food establishments, is increasing. It would be interesting to see how much of the increase is due to the use of woodfuels. Apparently, food vendors and eateries, particularly those in the informal sector which form the bulk of food establishments that the majority of the city dwellers patronise, will use woodfuels as long as they are cheaper than conventional fuels.

5.5.5 Household-based Livelihood Activities

Many households in both urban and rural areas are involved in livelihood activities that consume fuelwood and charcoal. Food preparation and the operation of small food establishments are the best examples. Usually, it is difficult to separate the amount of energy used for the livelihood activity from that used just by the household. In many cases, energy is consumed mainly for cooking and both the food to be sold and to be eaten are cooked at the same time. Thus, in surveying such households for their energy consumption, the amount consumed is usually labelled only for household energy consumption. In order to lower their operating costs and increase their profit these households (which probably can afford to purchase all types of fuel) generally prefer to use woodfuels as long as they are cheaper. If many such households exist in a locality being surveyed, the total household energy consumption will likely be overestimated.

5.5.6 Use in Industries and Enterprises

Fuelwood, charcoal and other biomass fuels are used in enterprises such as brick-making, lime production, textile processing, and food industries. When compared with the domestic sector the amount of woodfuel used by woodfuel using industries and enterprises appears small but nonetheless it is significant. Many of these industries and enterprises use outdated and inefficient wood energy devices.

Given the impacts of increasing population, economic growth and urbanisation, there are at least two sub-sectors which need closer study: the brick making industry and food establishments. Bricks are one of the major materials needed for the increasing construction activities in both urban and rural areas in the region. The brick industries in most RWEDP countries still significantly rely on woodfuels for their kilns. The significant role of woodfuels in the operation of food establishments has already been pointed out.

The use of woodfuels and other biomass fuels in industries and enterprises will depend on the price and supply security of these fuels relative to commercial fuels. These industries and enterprises will continue to use wood and biomass fuels as long as these fuels are competitive and supply is secure.

5.5.7 Modern Applications of Wood Energy

In the past few years, several countries in the region have become involved in modern applications of wood energy. These are not research or pilot projects – these are actual investment projects that exploit wood and other biomass fuels to generate heat, steam or even electricity for use by industries through more efficient, convenient and modern technologies. These projects are proving to be technically successful and economically profitable. They are showing what the role of wood energy could be in the future. They are also proving that wood energy can be a technically efficient, economically viable and environmentally sustainable fuel option.

5.5.8 Prospects for Traded Woodfuels

The factors that will drive continued or increased use of traded woodfuels are relatively lower woodfuel prices, a growing population with a larger segment still falling below incomes at which conventional fuels are unaffordable, constraints in the supply of conventional fuels, and increased acceptance of modern wood energy technologies. Consumption in households and traditional industries and enterprises is affected by the first three factors. Consumption for modern applications is affected by the first and the last factors. In the near future, the bulk of the consumption of traded woodfuels will still be in households and traditional industries and enterprises.

An analysis of consumption trends should be relatively easier for traded woodfuels than for non-traded woodfuels. The key parameters that determine traded woodfuel consumption such as household income levels and fuel prices can be quantified with a greater degree of agreement. However, most countries do not have data that relates income levels with fuel prices and energy consumption, particularly data that deals with woodfuels. And almost no country has historical data which can serve as a basis for consumption projections.

The situation is still more complicated for non-traded fuels, where very few data exist. Even if woodfuel trading is occurring, it is very much part of the informal sector (and sometimes and in some places, even illegal). There are no records of transactions available, unlike those for commercial fuels, electricity or commercial wood products. Furthermore, as with non-traded fuels, consumption patterns for traded woodfuels are very site-specific and any studies of such patterns require a decentralised approach.

Nevertheless, trends in changes in the patterns of households income levels point to at least continued significant use of woodfuels. As already mentioned, a large segment of the population in most countries will continue to be living at low income levels which will not allow them to shift to conventional fuels. The issue is how many households will be forced to gather woodfuels compared to households which will still be able to afford to buy woodfuels.

The effect of fuel prices does not appear to be straightforward. Nominal woodfuel prices are increasing over time in many places. In some places, its real price is even higher than that of kerosene. However, in spite of this, it appears that low income families still prefer woodfuels since they can purchase them in small amounts and, more importantly, many families are still too poor to buy kerosene stoves.

Increasing woodfuel prices will affect most industries and enterprises. They are more sensitive to fuel prices and have an appreciation of the trade-off between investing in a conventional energy device and paying a higher operating cost due to higher woodfuel prices. However, because of problems in supply security for conventional fuels they may opt to continue to use woodfuels.

This attempt to analyse the future of woodfuel has proved extremely difficult due to a lack of relevant data. As previously mentioned, such an analysis ultimately needs to be site-specific. This implies the need to develop the required technical skills among the wood energy-related institutions in RWEDP member-countries.

Box 2

Fuelwood in Agroforestry

In Asia, agroforestry systems are distinguished as either (a) farm-based or (b) forest-based systems. The former covers trees in home gardens, trees in agricultural fields, agricultural crops planted under commercial trees, commercial crops under tree shade, trees around agricultural fields, woodlots, and other farm-based silvicultural practices, as well as integrated fish ponds. The latter systems include the *taungya* system of forest plantation, shifting cultivation, silvopastoral practices in forests, and silvofishery.

In Sri Lanka, the Philippines, Vietnam and particularly West Java, Indonesia, agroforestry represents a substantial part (12-45%) of total land use. In these as well as other countries, agroforestry is a very important source of woodfuels. The supply of woodfuel per annum varies widely depending on, for example, climate, soil, species and tree density, but can be as high as 42 t/ha (*Calliandra calothyrsus* in agrisilviculture systems in humid climates) or even 58 t/ha (mangrove in silvopastoral systems).

RWEDP has evaluated the average woodfuel productivities of agroforestry systems in different zones. The results are presented below:

Climate	**System components**		
	Agrisilviculture	Silvopastoral	Agrisilvopastoral
Humid	14.1 t/ha	19.5 t/ha	12.9 t/ha
Subhumid	7.8 t/ha	7.0 t/ha	2.9 t/ha

The data are derived from existing systems and it should be emphasised that most of these systems are not cultivated with the sole purpose of providing wood, but are supplying fodder, grains, tubers, vegetables, various animal products, etc., under various farmland resources management systems.

The minimum land area under agroforestry required to meet the woodfuel needs of one household has also been calculated. The results are presented as follows.

Climate	**System components**		
	Agrisilviculture	Silvopastoral	Agrisilvopastoral
Humid	0.21 t/ha	0.20 t/ha	0.20 t/ha
Subhumid	0.60 t/ha	0.59 t/ha	0.95 t/ha

It is concluded that agroforestry systems are already very important woodfuel suppliers and have the potential to meet woodfuel demand in most Asian countries. The data suggest that this would be possible if farmers adopted appropriate agroforestry practices on 20-30% of their agricultural land holdings in humid zones and on 25-50% in drier areas. In most RWEDP member-countries, there is no shortage of land available for agroforestry extension.

Source: "Woodfuel Productivity of Agroforestry Systems in Asia", Michael Jensen, RWEDP Field Document No. 45 (1995).

6. WOODFUEL SUPPLY POLICIES

6.1 Current Issues

6.1.1 Supply Sources and Sustainability

The main sources of woodfuels include natural forests, government and private tree plantations, community forests, village or private woodlots, scattered trees in farm boundaries, canal and river banks and road sides, and private trees in homesteads and homegardens.

The share of non-forest areas in the total woodfuel supply is substantial. This information is very important for evaluating the sustainable use of biomass energy in the region. It is now obvious that "the other energy crisis", i.e. the woodfuel crisis, in developing countries, which was predicted in the mid 1970s because of massive deforestation, has not taken place as was predicted. In no country has the natural forest areas disappeared completely. Despite a continuing problem of growing stock depletion, primarily due to changes in land use, unsustainable harvesting of forest products, open grazing and frequent occurrence of fires in natural forests(which have been the most important issues affecting sustainable forest management in tropical countries) most countries have also been able to expand the area under tree cover through massive afforestation or reforestation programmes.

Non-industrial tree plantations and private and community woodlots, including scattered or linear tree plantations on privately owned or community managed lands, have contributed significantly to the supply of wood in recent years. In many RWEDP member-countries massive tree planting programmes under social or community forestry development and non-industrial tree plantations of commercial importance have played a great role.

Data (published by RWEDP (RWEDP, 1996) on the non-forest supplies in eight countries are summarised in Table 4.2. The contribution of non-forest supplies in other countries is still not known. For the time being, the average for all RWEDP member-countries is estimated to be two thirds of the total supply (i.e. 68%, based on a consumption-weighted average of the available data). These sources may ensure a sustainable supply of woodfuels in the coming years, thus delinking deforestation from wood energy use.

Firewood derived from tree stems, branches and stumps is the commonly preferred fuel amongst domestic users of biomass fuels. However, only the better-off households can afford them. Many users do not own private trees and lack access to them for getting the preferred type of woodfuels. They also lack surplus cash to buy woodfuels in local markets. The part of the population which lives below the poverty line uses biomass residues of various types, which are often perceived as inferior fuels. Furthermore, many poor people in large urban centres try to meet their fuel requirements by collecting freely available waste wood, or by cheaply purchased recovered wood from old construction activities.

These types of biomass fuels may be in the form of:

a) Fallen leaves, needles, twigs, and branches of standing trees

b) Left over wood and branches after commercial harvesting of forests

c) Crop residue of different kinds, including stalks, straw, husk, shell and cobs

d) Grasses

e) Industrial residues in the form of saw dust, off-cuts, bagasse, coconut fronds

f) Discarded waste wood from different sources (e.g. old furniture, recovered wood from old construction activities, drift wood).

When the above types of fuels and their supply sources are included in the statistics of biomass fuel production, the share of forest produced woodfuel becomes rather insignificant indeed. For a large proportion of the poor and marginalised farmers in Asia, the other biomass sources provide the fuels for subsistence. Therefore, the importance of biomass fuel is not expected to diminish as long as the problems of poverty and marginalisation prevail in Asia. The poor and the marginalised farmers should in no case be blamed for deforestation or forest depletion. They are neither the consumers of the bulk of traded woodfuels, nor are they responsible for illegally harvesting and using the large size high value trees standing in forests and plantations for domestic fuel supply. Indeed, they lack the access, tools and cash to harvest the resources, which only the contractors and traders of woodfuels can afford.

Biomass residues represent one of the essential components of farming systems, primarily in upland (mountainous) ecosystems. A significant portion of the residues is applied to the soils to replenish nutrients consumed in crop production. Excessive use of residues for other purposes may be detrimental to the maintenance of farm productivity in fragile ecosystems. Of course, with improved irrigation and additional farm inputs, productivity of land and residue production could be enhanced, which could supply additional subsistence energy to farmers and the poor, as well as to modern commercial applications. These issues deserve serious consideration in sectoral planning for energy and agriculture. In the calculations by RWEDP, presented in Chapter 8 of this document, a conservative estimate is used for potential use of crop residues for fuel (i.e. only 50% of processing residues, and leaving field residues untouched).

6.1.2 Traded Versus Non-traded Supply

Most woodfuels consumed in rural areas originate from private or public sources. With the recent thrust of economic liberalisation and open market policy in most RWEDP member-countries, private sector participation in commercial tree farming on privately owned land, harvesting, conversion and transportation of privately raised trees and commercial trade in wood and related products is becoming more and more possible. However, many restrictions still exist which limit development in the sector. In most countries, even today, prevailing regulations governing privately raised tree harvesting, conversion and trade are very conservative. Most seem to restrict the free movement and trade in wood and related products via open marketing channels. According to their proponents these restrictions are to control deforestation caused by illicit cutting and smuggling of forest products from government owned and managed natural forests and plantations.

Despite many restrictions, trade in privately produced wood and woodfuels is penetrating into the local markets which used to receive the supplies either through vendors or government established corporations. Many vendors also acted as collectors, transporters and sellers for the informally traded woodfuel, and they mainly serviced the household sector. The government run agencies, on the other hand, procured the woodfuel they supplied from government forest departments. The major clients of the formally traded woodfuels are the military and police establishments, student hostels in colleges and institutions, food and catering services in towns and large urban centres, and woodfuel based industries of various kinds. These markets are now receiving additional supply of woodfuels from private producers. As a matter of fact, without the urban and industrial users the prospects for private sector participation in commercial wood energy development seem bleak.

For most of the domestic woodfuel consumers, who are primarily the rural people and the poor in larger urban centres, woodfuel is still a free good that can be collected at the source. As long as such situations prevail, no large scale commercial investment will be feasible for wood energy development in the region.

Furthermore, an increasing number of agro-processing industries meet their energy requirements by using residues generated by their own operations (e.g. sugar mills, rice mills, palm and coconut oil mills), and others obtain firewood when replacing fruit orchards and other non-industrial tree plantations (e.g. rubber and coconut). These supply sources are slowly gaining recognition in terms of their important supplementary role in woodfuel supply, particularly in forest deficit and non-industrial plantation dominated areas.

6.1.3 Wood Energy, Poverty and Rural Employment

As stated, only a limited segment of the users purchase the woodfuel they consume in markets. Others either hire paid labour or collect woodfuel themselves from available free supply sources. A significant portion of the rural population is employed in these tasks, and for some of them it is the only means to earn cash income.

Biomass residues and by-products derived under different systems of land management remain the only fuel option in the short term for subsistence energy for the poor and marginal farmers in rural areas. In areas where commercial production of woodfuel is not feasible and where woodfuel is not yet a tradable commodity, participatory management of degraded natural forests through local forest user groups is the only hope for enhancing the supply to these farmers. In such areas community or social forestry development strategies have proven a great success. In areas where commercial woodfuel production potential is high and trade in woodfuel insignificant, the going market price also promotes new investment in the establishment of fast-growing dedicated woodfuel plantations or in the integration of multipurpose trees into farming systems. These opportunities can be utilised to create new jobs for the poor and marginalised farmers. Since tree planting, maintenance, harvesting, processing, conversion (also into charcoal), transportation and trade of wood and fuelwood provides a substantial amount of new employment in rural areas, this opportunity should be utilised to its maximum for poverty alleviation.

It is estimated that the labour employed in the woodfuel business per unit of energy consumed is 20 times greater than that for kerosene, which is its closest substitute among the commercial fuel substitutes. In all RWEDP member-countries, a large number of people are involved in work associated with the production, conversion, and flow of woodfuel and other related activities. Employment data, previously published by World Bank/ESMAP in 1991, are summarised in Table 4.3 (see p. 23).

For most countries in Asia it may be wise not only to opt for a strategy that enhances woodfuel production, but also to implement wood energy related development programmes for poverty alleviation. Similarly, woodfuel utilisation in industrial activities can contribute significantly to poverty alleviation in rural and urban areas. Other activities in the wood energy sector of importance to poverty alleviation include improved cook stove production, wood energy based food and agricultural products processing, and mineral, metal, textile, and wood production.

6.1.4 Environmental Implications of Woodfuel Use

There are both negative and positive implications of the widespread use of biomass fuels. Increasingly, concern is being raised about the negative health impacts of traditional fuel use in the domestic sector. Several studies indicate that, besides the hardship associated with gathering and cooking, indoor air pollution associated with biomass fuel use in open hearths and non-ventilated kitchens induces health related problems particularly for women, lactating children and the elderly.

A disputable negative environmental concern related to woodfuel use is deforestation. In vulnerable watersheds or catchment areas and in ecologically sensitive or protected areas located in the environs of heavily populated villages or urban centres, where the use of traded woodfuel by the household and industrial commercial sector is significant, continuing use of unsustainably harvested woodfuel may be one of the many significant causes of deforestation at the local level. However, it is not the sole cause of deforestation everywhere else. Many studies increasingly support this view, and categorically state that deliberate conversion of natural forest lands into agriculture and other uses is the foremost cause of deforestation in the countries and areas covered by these studies.

In the context of growing concerns about global warming and world climate change due to increasing emission of CO_2 and other greenhouse gasses into the atmosphere by fossil fuels, the thrust of development in the energy sector is now for development of renewable sources of energy. Therefore, extended use of wood energy is gaining widespread support as live trees and vegetation serve as sinks and reservoirs of carbon. If sustainably produced and utilised, wood is a carbon neutral source of energy. The relationship between woodfuel use and global warming is dealt with further in chapter 9. The strategy of environmentally friendly development in the energy sector is being successfully implemented in several European countries (particularly in Nordic and European Union member-countries), in some countries of South America, and in the USA. Some Southeast Asian countries, i.e. Indonesia, Philippines and Thailand, have already initiated pilot scale adoption of new energy technologies through private sector participation.

Wood is an important source of energy in Europe. Over 45% of the volume of wood removed annually is used for energy, either in its conventional fuelwood form, or as residues of wood industries, or as recovered used wood. The main consumer of wood energy, there too, is the household sector in rural areas (about 65%). The other users are forest industries (27%) and other intermediate consumers like district heating plants and community buildings (8%). (UN/ECE and FAO, 1996).

However, the issue of boiler emissions of volatile hydrocarbons (VOC), which are responsible for "blue haze" and are also produced from wood burning, has been raised as a possible limiting factor for expanded use of wood energy in the future without technological advancement for emission control.

In Asia, the application of modern biomass energy technologies is expected to accelerate to resolve the problems of energy shortages and to meet the growing demand from newly emerging industries. A new prospect has been opened-up by the successful implementation of pilot plants that use modern cogeneration technology. The prospect of expanding modern technological options in wood energy development looks quite promising in some Southeast Asian countries, particularly in Indonesia, Philippines and Thailand. The technical options seem suitable to new wood industries which can generate a sufficient amount of wood waste and residues for cogeneration, or in existing industries willing to invest in innovations to make the industry self-reliant in energy. In all cases, the primary thrust is to make optimal use of available wood waste for energy production.

The prospect of excessive or overuse of available biomass (woodfuel and residues) can not be ruled out in the absence of national policies which prevent unsustainable use. It could also affect prevailing farming systems in upland ecosystems where farm productivity is to a great extent maintained by applying biomass residues. Full or excessive utilisation of residues for other purposes could have an adverse impact on the fragile environment.

6.1.5 Availability, Accessibility and Affordability

User preferences for various types of biomass fuels depend largely on local fuel availability, accessibility and affordability. The three factors are interdependent.

Accessibility can significantly limit the availability of fuelwood in a certain area, even where a large tract of natural forests exists in the neighbourhood. For example, people living in areas close to classified natural forests or protected areas (e.g. designated national parks or wildlife reserves, strict nature reserves or biodiversity conservation areas, and important catchment areas or watersheds), no matter how big the forest area may be, sometimes have no or limited right of access to resources to meet their basic needs for forest products, including fuelwood. Natural physical barriers (due to difficult terrain, steep topography, cliff and big river crossings, etc.) also limit the access to local resources. Seasonal variation in climate may act as a further hindrance.

Household decisions are influenced by economic affordability when choosing types of fuel amongst the available options. This is a major factor determining local fuel use patterns. Affordability may be defined in terms of cash, or time required for self-collection of firewood, or for collection through hired labour. A related factor which affects woodfuel supply is the cost of transportation. Fuelwood is a "high volume low value" good and faces economic limitations in long distance transportation. Woodfuels for subsistence are typically acquired within a range of

15-20 km from the user, whereas commercial woodfuels are normally acquired within a range of 80-100 km. In limited cases woodfuel is transported over long distances, e.g. as a load on an empty truck on a return journey.

Further factors which can affect the level and patterns of fuel consumption include demographic characteristics, food preferences and local cooking habits, culture, tradition and rituals, climatic conditions and seasonal variations. These factors may limit the amount available as woodfuel, both for local collection and for market trade. The going market price tends to reflect local people's capacity to purchase these products, if no other forces interfere from outside.

Though availability, accessibility and affordability affect the choices of fuel users, most users prefer woodfuel (firewood and charcoal) over inferior biomass fuels. This places woodfuel high up on the "preferred fuel ladder" as compared to traditional fuel substitutes.

When traditional woodfuels are converted into modern forms of energy, due consideration should be given to the needs of the poor and their problems of availability and accessibility. Industrial commercial sectors are generally better placed to make use of commercial wood energy than the traditional woodfuel users in the domestic sector. As the residues of various kind are currently being used in most South Asian countries, future commercial application of scattered residues (produced in smaller dispersed locations) can create further hardships for poor and marginal farmers.

6.1.6 Woodfuel as a By-product

In Asia, the bulk of the woodfuels harvested is still a by-product of various types of forest and tree-based agricultural land-use systems. The systems include management of natural forests, tree plantations, and naturally growing trees and shrubs in public, private or community owned/managed lands for multipurpose production objectives. Establishing large-scale, fast-growing woodfuel plantations exclusively for the purpose of supplying woodfuel to the domestic sector is a strategy for rural energy development still to be tested for financial feasibility.

Some RWEDP member-countries which were following a centrally planned economic system, have established substantial areas of new tree plantations with the prime objective of fuelwood supply (e.g. the Firewood Forest Construction schemes in China, and the massive reforestation and afforestation campaign and the scattered tree planting programme in Vietnam). No other country has established such extensive areas for single purpose woodfuel plantations. However, even in China and Vietnam the main product of the wood harvest is used for construction or as industrial raw material after the trees grow to harvestable age. Only the logging residues and industrial wood wastes are used as fuels, as by-products.

Social or *community forestry development programmes,* though initiated primarily to address the issue of fuel supply in the domestic sector, have now become popular, and successful, all over the region. However, here as well the major share from the output of community forestry schemes seems to be unavailable to local users as woodfuel, as was envisaged during the conceptualisation stage of this strategy. The initial thrust of these schemes was to meet the basic energy needs of the rural people through their active participation in every stage of forestry development. The concept was linked to an international strategy to overcome the expected fuel crisis in developing countries immediately after the international price rise in petroleum fuels in the early 1970s. Experience of the last decade suggests that the major share of the wood harvested from these schemes cannot compete as firewood because other end-users are willing to pay higher prices. Therefore, only whatever firewood is sold at the logging site by forest departments or whatever is available as leftover wood, will be used for energy.

Homestead and home-garden systems of land use are more prominent in tropical countries than in those with milder climate (particularly in India, Indonesia, Philippines, Thailand, and Sri Lanka). These systems, together with traditional agroforestry practices integrating fruit and multipurpose trees into the farming systems in drier regions and highland or mountainous areas, are successful examples of people's subsistence needs-based land management systems that prevail in the region. The multiple products derived from trees provide food, wood and fuel to the people, fodder to the livestock, and vegetative protection to the land – which is a time tested strategy of self reliance.

The recently expanding non-industrial tree plantations in the countries of Southeast Asia (e.g. coconut, rubber, and oil palm plantations mostly in Indonesia, Malaysia, Philippines and Thailand) have become additional supply sources of wood and by-products. Similarly, in some South Asian countries, the new participatory forestry development strategy of "care and share", is gaining increasing recognition for its success in the management of degraded natural forests. The strategy tends to identify the historical users or right holders in such forests and allows their active participation in management and benefit sharing. Examples are the Joint Forest Management (JFM) system in India, the User Group management system in Nepal, and the participatory agroforestry development system in Bangladesh for management of degraded *"Sal"* forests.

It must be concluded that fuelwood in most Asian countries is not a main product but only a by-product from forest and timber processing. However, it is an important by-product. It is estimated that up to 30-40% of the above ground biomass of a tree comprises small size wood (from stem and lops and tops) and bark, which would be available as fuelwood at the felling site and would not be suitable for conversion into sawn timber. Of the commercially important sawn wood recovered after forest harvest, again a major share (between 30-70%) will be available as wood residues or processing waste (i.e. slabs, off-cuts, sawdust, wood strips/chips, etc.), depending upon the recovery efficiency of the technology applied in processing (in primary, secondary and tertiary processing). When added together, as much as 80% of the total wood harvest may be available for fuel purposes. If one further takes into account the ultimate use of all products made of wood, the recovered wood from old construction activities and objects, virtually every piece of wood harvested from a tree becomes available for fuel, as a by-product sooner or later.

6.2 Prospects

6.2.1 Aspects of Supply Enhancement

The development strategies and programmes in the forestry sector, e.g. Forestry Sector Master Plans (MPs); Tropical Forestry Action Plans (TFAP's), and more recently the National Forestry Action Plans (NFAP's) after the Rio Earth Summit of 1992, all recognise the depletion of natural forests due to deforestation and over-use. They all call for the initiation of sustainable management of the remaining natural forests and man-made plantations. To protect fragile ecosystems and to meet the basic needs of local people, they recommend an enormous expansion in the rate of tree planting, in which the participation of local forest user groups or the private sector is considered a prerequisite. To overcome woodfuel shortages, most plans recommend a three-pronged approach:

a) Demand management through introduction of technology to reduce woodfuel use by more efficient cook stoves

b) Supply enhancement through improved distribution systems and increased production management of natural forests, new reforestation and afforestation, private tree planting, etc.

c) Development of alternatives, e.g. commercial utilisation of wood-waste for energy by densification or cogeneration, and development and promotion of non-conventional renewable energy.

However, it is observed that most of these approaches eventually fall short of expectations, because the intended beneficiaries appear to have limited access or capacity to acquire the new resources developed. Commonly perceived constraints include socio-economic and institutional factors (in government and non-government sectors), support services, incentives and motivation (e.g. credits and inputs), manpower and training. These factors will be discussed further.

Social:

The low socio-economic status of most traditional fuel users puts them in the position of free collectors of woodfuel rather than consumers of traded fuels. The amount of woodfuel they consume does not enter into the marketing chain, nor does it get recorded in official statistics.

Related to low socio-economic status and poverty is a chronic hunger for land in most countries for increased agricultural production to feed the growing population. This puts most countries in a situation where large areas required for developing fast-growing commercial woodfuel plantations are unlikely to be available. Private land holdings (including all types of land whether cultivable or not) are, on average, very small (less than one hectare in total). Some countries rich in degraded forest area or waste lands have been trying to convert them into tree plantations (e.g. China, India, Indonesia, Malaysia, Philippines, Thailand). But most other countries can only find some scattered plots of a few hectares to convert into community or village woodlots. Of course, in most countries the prospect of managing degraded natural forests and the development of agroforestry land use systems is high.

Economic:

A number of questions can be raised regarding the economic development potential of woodfuel, such as: will it be economical to raise large-scale fast growing woodfuel plantations on public land (forest or community land) purely from the point of view of producing cheap energy to supply rural households? If so, under what conditions will it be feasible both financially and economically? If not feasible, what alternative opportunities exist in terms of woodfuel supply enhancement, purely for meeting the subsistence energy needs of rural people? Should there be specific programmes for urban consumers of woodfuel (including domestic, industrial and commercial applications) which is traded in the market? If yes, what is the maximum price people will be prepared to pay for woodfuel produced commercially?

These economic issues need to be critically analysed when formulating strategies at the country level to enhance woodfuel production. Application of internal economic rate of return (IERR) analysis during project design alone should not be the factor to justify investments in large-scale fast-growing woodfuel plantations. Since most of the domestic sector woodfuel users in rural areas will not be in a position to pay the economic price of woodfuel produced in such large-scale plantations, the issue of long-term sustainability of the strategy remains unresolved.

Current international prices of petroleum fuels, prevailing subsidies on commercial fuels, the long gestation period of woodfuel plantations, high conversion and transportation costs, all tend to limit the development potential of high investment woodfuel plantation projects in Asia. The present perception of biomass fuel as a “cheap and dirty” source of energy does not favour cost recovery from expensive plantation projects. Moreover, part of the economically better off section of the society may switch to other “clean and modern” commercial energy substitutes.

At the level of the national economy, woodfuel use contributes to improving the balance of payments, by import substitution through the use of indigenous renewable energy resources.

Physiographical:

As mentioned above, natural or man-made physical barriers together with other factors related to climatic and seasonal variations, also affect the availability, accessibility and affordability of woodfuel to users. In some cases it will not be possible to supply woodfuel, no matter what price the users are willing to pay locally. Poor infrastructure, difficult terrain, long distance from supply sources and high transportation cost all add to the limiting factors of availability, accessibility and affordability.

Technological:

Traditional biomass energy conversion technology is primarily based on direct feeding of crude or partially processed fuels into the stove, hearth, fireplace, furnace or boilers, for producing heat and/or shaft power for cooking, processing or manufacturing. In the long-term, these technologies tend to phase out slowly, and upper and, indeed, middle income groups in large urban centres and towns are already showing signs of energy transformation, particularly in the household sector. As modern industries do not favour the use of crude biomass in its traditional forms, consumption in the future may depend upon the level of introduction of modern energy technologies in the industrial commercial sector. But at the same time, as long as these traditional types of processing and manufacturing activities continue, the demand for woodfuel will also continue, and probably even increase in absolute terms, due to population growth and growth in the demand for these products. The demand for woodfuel will be supplied from whatever production sources are accessible and the cost may increase as more and more distant sources are exploited.

Despite technological advancement, application of biomass fuels for conversion into modern commercial energy is making only a slow intrusion into the region, mostly in some countries in Southeast Asia. Even there, public sector agencies related to energy development have yet to fully recognise the potential contribution of the innovations. In most other countries, even basic domestic biomass fuel use technology is yet to be developed and disseminated, both for improvement of cooking conditions and for fuel efficiency. Due to limitations of land availability for establishing large scale woodfuel plantations, the potentials in the region seem to be confined to the application of residues produced by wood-based industries and the agricultural sector.

Further, modern biomass energy development technologies developed in industrialised countries may not suit local conditions, particularly in terms of operation and management, maintenance, backstopping arrangements, etc. Research and development in biomass energy applications does not yet receive significant budgetary support. Basic knowledge on biomass densification, gasification, combustible vegetable oils, etc. is still limited in most countries in the region.

Institutional:

Until recently, in virtually all countries, only the government forestry departments had the authority to harvest and trade wood and related products. These agencies, during the commercial harvesting of trees in natural forests or plantations, convert only the branches and small size stem wood into woodfuel. The primary concern of most forest departments in the region was, and still is, to produce high value commercial sawn wood, and not woodfuel. And wherever a market for woodfuels did not exist, they simply left such wood in the forest as logging residues. Local users were allowed to collect it later, either freely under their right and concession to adjoining forests or with payment of nominal royalty fees to the government.

The role and potentials of the private sector to contribute to wood energy development is not yet fully recognised. So far, the responsible agencies in the public sector tend to act more as controllers than as development promoters of biomass energy. Negative aspects of biomass fuel use seem to be published more widely than their positive contributions, and often with much exaggeration. The most common misconceptions concern woodfuel induced deforestation and environmental degradation, the impoverishment of soil nutrients and adverse effects on agricultural production due to continuing use of biomass residues, and the use of woodfuel contributing to greenhouse gas emissions. This misinformation induces restrictions of different kinds, governing the ownership, and harvesting of trees and the movement and trade of privately produced wood and fuelwood. These are clear manifestations of institutional problems.

The need for inter-agency co-ordination and collaboration in wood energy development is slowly being felt and gaining recognition in the region after initiation of activities by FAO/RWEDP in the mid-1980s. Still, a clear policy at the national level regarding wood energy development is lacking in most of the member-countries. Neither the energy sector nor the forestry sector bears a sole responsibility for wood energy development.

Policy and Legislation:

Prevailing policy and legislation governing land, forest and tree ownership and tenancy is not clear, forestry and agriculture sector policies are uncoordinated if not contradictory, and the energy sector still seems reluctant to come forward to give its unqualified support to wood energy development.

Education and Training:

Forestry and agroforestry related education and training programmes in the region do not yet recognise the need to include subjects related to wood energy development in their training curricula. Training in the power and energy related institutes generally care more about non-conventional renewable sources than wood energy.

Advances in terms of incorporating wood energy subjects into forestry training have been made so far in some countries only (e.g. PFI, Pakistan; UPLB, Philippines). Not enough information is exchanged on these important developments in the region. RWEDP's recent effort has played an instrumental role in identifying the gaps.

Information:

Information is still limited regarding the supply side of wood energy systems, especially forest and non-forest area based production and flow systems. This affects the planners' efforts to project energy demand/supply balances based on sustainable supply potential, and affects farmers and traders by restricting their knowledge of the size of the existing fuelwood market, woodfuel prices and pricing mechanism.

Extension and Support Service:

In today's competitive world, whatever crops cannot be sold will not be raised and whatever has the potential to attract higher market prices will be raised by most farming communities as well as private sector investors, even if there could be a risk of over-supply in the market. This aspect is becoming more and more visible in forestry related developments too. The successful and commercially motivated agroforestry development in selected parts of India, Pakistan and other countries, and the expanding non-industrial tree plantations primarily in Southeast Asian countries are the visible examples of the changing trend in farming systems and land use in the region.

Extension and support services in the region in support of wood energy development are limited. These are generally under community and social forestry or agricultural extension packages which do not necessarily address the specific issues of woodfuel production enhancement through improvement of the current woodfuel production, flow and utilisation systems.

Incentive/credit:

Farmers lack incentives and motivational packages to adopt a wood energy development programme as a productive undertaking. Available inputs are only minimal, mostly limited to the supply of seedlings for planting. Credit and subsidy programmes do not cover the financing of commercial tree planting in private or community lands. Private sector interest in investment in single purpose woodfuel plantations for commercial motives is almost non-existent. Support available to farmers in terms of management of existing home garden or homestead trees for sustainable production and utilisation of multiple of products is rare.

Different types of indirect taxes levied on woodfuel by different agencies (e.g. national and local government bodies, and social organizations), particularly during different stages of production, movement and trade, raise the market price of woodfuel, bringing it on a par with, or even more expensive than, commercial fuel substitutes.

6.2.2 Strategies for Supply Enhancement

Woodfuel Supply for Subsistence:

Enhancement of supply in rural areas, where woodfuel is yet not a traded item, will be difficult without its integration into local farming and forestry management practices. Where woodfuel is collected mostly free of charge for subsistence, no prospect exists for its commercial production in the short-run. In such a case, local people's participation in the sustainable production and utilisation of woodfuel from locally available resources (mostly from existing natural forest and shrub/scrub and waste lands, as well as existing depleted natural forest and shrub/scrub lands) does not appear to possess the potential of producing additional woodfuel production. But, tree planting in community wastelands could contribute to the development of new supply sources in the form of village or community woodlots. Therefore continuation of the prevailing programme of social/community forestry, which primarily aims to promote participatory forestry development schemes, may be the most feasible low-cost strategy to meet the basic subsistence energy needs of the poor and small farming communities in rural areas.

"Joint Forest Management (JFM)", the "User Group" managed natural forests or block plantations, and many other successful forms of participatory forestry strategies should continue. They not only help local people to satisfy their basic needs, but also contribute to forest and local ecosystems protection - a serious problem for most governments.

The other strategy which may be of importance to both subsistence and traded woodfuel supply, is the continuation of traditional agroforestry practices that incorporate woodfuel production within the ongoing farming system and this should be given as much support as possible to promote its development. This strategy would ensure the supply of locally needed woodfuel by conserving supplementary production sources. And in the meantime, it will also complement the local market by making available additional woodfuel from non-forest sources, wherever opportunity exists for woodfuel trade.

Supply of Traded Woodfuel:

The demand for market traded woodfuel is also not expected to be met (at least in the short term) by the development of new supply sources in the form of large-scale woodfuel plantations. Public supply sources, particularly government managed forests, however, may still continue to be major suppliers as far as woodfuel used by institutions and traditional industries are concerned. Hence, the sustainable management of existing natural forest and plantations is necessary to at least partially meet the market demand for woodfuel. Public supply sources should even be managed from the point of view of price maintenance in the short run in order to supply the urban poor with woodfuel.

As mentioned earlier, non-forest supply sources play an important role in woodfuel markets in many countries. Therefore, considering the potential that exists for making additional income to investors from the sale of by-product wood from private trees and non-industrial plantations, these practices should be allowed to continue and should be promoted as a strategy for enhanced woodfuel production. But this strategy of additional woodfuel supply source development may only work as a component of different agroforestry practices, or under other multipurpose tree-crop based production systems (i.e. non-industrial plantations of coconut, oil palm, rubber, fruit orchards, etc.).

To successfully implement these strategies in areas where commercial trade of woodfuel is possible, private sector investment in woodfuel production should be promoted by clearing obstacles created by policy, legislation, institutions, cross sectoral implications, etc. and by supporting the free flow and trade of woodfuel from the producers to the users. The government's priority should lie not so much with imposing controls or restrictive measures, but with promoting the identification of new support services, incentives, etc. Indeed, the government should initiate large scale farms, blocks, strips or agroforestry development schemes, perhaps under a separate commercial programme package outside the influence of social forestry programmes, and provide the necessary support for their further development.

As stated, large-scale plantation programmes for wood energy may not yet be feasible for investment in Asia. Many factors, which may be acting singly or in combination as well as directly or indirectly, are responsible for the current limited success of fast growing fuelwood plantations in the region,. Furthermore, one has to ask: To meet whose demand is one trying to identify the supply sources and at what cost? These issues must be considered thoroughly when planning a strategy for wood energy development in arable lands that have competing uses.

Need for Integration:

Integration will be necessary not only between different sectors related to wood energy development (i.e. energy, agriculture, rural development, etc.), but also between the various development plans and programmes within the forestry sector (i.e. natural forest management, plantation development, social or community and private forestry development, etc.). And for the effective integration of wood energy into the policy, strategy, plans and programmes of forestry development, it will be essential for foresters to recognise the role and importance of wood energy in the national economy and environment (including in the rural socio-economy and in efforts at poverty alleviation). Such support may also contribute to sustainable utilisation of forest and community lands.

The issues that persist in the forestry sector, which may be addressed through incorporating wood energy into the development policy, strategy, plans and programmes of the sector include:

- The pressure of unsustainable fuelwood collection in the designated national forests, protected areas, commercial plantations, and other environmentally sensitive areas;

- The need to enhance sustainable wood production for multiple uses through people's participation in forest protection and sustainable management;

- The problem of open grazing and fire in the forest, which are among the major causes of forest depletion – a chronic problem in virtually all forests solely managed by forest departments;

- The need to develop available waste lands and degraded forests which are easily accessible to local communities into productive, multiple use forests/plantations through afforestation, reforestation and/or natural regeneration with community participation in management and sustainable utilisation.

Need for Support at National and International Levels:

So far, neither the national policy of governments in the region nor the regional and international development assistance agencies seem to consider adequately the role and prospect of the wood energy sub-sector, hence they lack a clear policy for making full use of the potentials of this sub-sector, both from the point of view of energy development and environmental conservation.

The positive benefits of an integrated wood energy development strategy include the promotion and development of private, community woodlots on private and community-owned lands that are currently not properly utilised, and the expansion of private-, farm-, and agro-forestry covered areas. Such a strategy would also support the conservation of soil, water and biodiversity. However, for this integrated strategy to be successful, a number of issues need to be addressed which impinge upon the mandates of many other sectors beside the forestry sector.

6.2.3 Recommendations

Taking into consideration prevailing wood energy systems in RWEDP member-countries, particularly the woodfuel production and flow systems (including supply sources and acquisition methods), a strategy of integrated woodfuel production in forestry development seems appropriate. Single purpose, large-scale fast-growing plantations as a strategy purely for the supply of fuelwood to the rural population seem, at this point in time, dubious. However, for the effective implementation of an integrated woodfuel production enhancement strategy, the issues raised earlier deserve immediate consideration from government agencies. Actions to be undertaken at the country level in the short-term, depending upon the local situation, may include the following:

1) Review prevailing rules and regulations and continue making amendments that govern the following: land ownership, holding size, and tree tenure; tree planting and harvesting in private and community lands; transportation and trade of wood and related products produced by the private sector or local community; use of by-products and residues from wood-based industries.

2) Recognise the role and importance of woodfuels produced in the non-forest areas and treat them as an important sub-sector which needs to be developed; remove capital cost and price subsidies, cross subsidies, etc. on commercial fuels, which may be currently acting as a disincentive to the development of renewable sources of energy (including wood energy).

3) Increase government investment and encourage community participation in woodfuel related development in those areas in which the private sector seems reluctant to invest (e.g. through community/social forestry); review peoples' existing usufruct rights and bring implementation strategies into harmony with the "care-and-share" philosophy; resolve the issue of equity in joint or community management of public resources.

4) Reform policy to induce private sector investment in wood energy development in areas wherever potentials for woodfuel trade exist, by providing support to private, community land based production enhancement, or through development of multipurpose tree plantations in public forests and leased lands; review existing direct and indirect taxes on wood and woodfuels produced in both forest and non-forest lands and make amendments in favour of making production and trade attractive for private sector participation.

5) As an immediate measure, simplify or abolish licensing and permit requirements for local production, transportation, trade and utilisation of woodfuels produced by local communities or in the private sector; ensure free and open trade mechanisms for all legally produced woodfuel and related products.

6) Continue present efforts in reforestation and afforestation; promote the development of pilot scale wood energy plantations with participation of the private sector and local communities, and, wherever feasible, arrange for credit and support services during the initial stage of their establishment as a test strategy for the future development of renewable biomass fuel based decentralised energy supply systems (e.g. through gasification or densification).

7) Treat wood energy as an important, not marginal, sub-sector requiring development when planning and allocating resources for the forestry, agriculture and energy sectors; expand awareness raising programmes on wood energy development.

8) Consider infrastructure development in areas where woodfuel is already a traded item and where potential exists for supply enhancement to meet the existing and growing market demand.

9) Support R&D on the selection of fast-growing tree species for wood energy crops, the identification of appropriate provenance to match specific conditions, and the improvement of the survival and growth rate of trees planted in degraded sites and waste lands, which are all relevant in terms of enhancing private sector participation in woodfuel production.

10) Support R&D for enhancing woodfuel production under prevailing and new agroforestry systems (in both private and public lands), and support the integration of wood energy production into non-industrial plantations.

11) Support the management of existing home-garden and homestead trees to maximise farmers' benefits, as well as to enhance easily accessible woodfuel production to reduce women's hardship.

12) Integrate wood energy into rural energy supply strategies and pursue it as a common task for all relevant sectors (e.g. agriculture, forestry, industry and energy sectors), by stating it in their sectoral policy documents.

13) Encourage the use of by-products and residues from wood industries to reduce wood waste; support local adoption of conversion technologies to enhance economic benefit to woodfuel producers.

14) Initiate management of existing forests and plantations for sustainable supply of woodfuels; remove all types of prevailing restrictions to convert genuinely acquired firewood into other economically feasible forms of wood energy (i.e. charcoal, producer gas, cogeneration, etc.), by applying known technology.

15) Establish or strengthen institutions for wood energy development; design extension and investment programmes to integrate wood energy into development programmes of related sectors; expand the scope and coverage of all existing outreach programmes to include and promote woodfuel production/wood energy development.

16) Strengthen woodfuel user–producer linkages by designing and opening access to credit and support services, buy-back price guarantee, etc. to promote private sector participation in tree planting for woodfuel production; improve the current "consumer governed" woodfuel marketing system to make it "equally friendly" to the producers of woodfuel.

17) Collect and disseminate information on management of private trees and block plantations to promote woodfuel production and trade in the private sector; wherever feasible, support the formation of tree farmers' co-operatives or associations to enhance their strength in the market.

18) Establish wood energy databases at regional, national and local levels and support private and public sector agencies related to wood energy development with information; integrate wood energy subjects in training curricula of relevant sectoral education and training.

19) Eliminate inter-agency mistrust and conflict of interest particularly between the two interrelated sectors of forestry and agriculture for effective integration of agroforestry practices into the farming systems: foresters should stop being non-supportive to programmes of non-forest land oriented wood resources development programmes, and agriculturists should stop regretting the slow intrusion of tree crops into farming systems affecting national food production. These unhealthy responses will not benefit either sector and both still have to make full use of the potential for production enhancement that currently exists in their respective sectors.

20) At the regional and international level, accept wood energy as an area for development; allocate additional resources to support every aspect of wood energy development, i.e. in implementation of activities at the field and credit assistance; in support of research and development; for institution building and manpower training; etc.

Box 3

Good News?

Urban people tend to believe that most woodfuels come from forests. It is one of the most persistent and disturbing misconceptions. Not all fish comes from the sea, not all fibres come from cotton, and not all chillies come from Chile. In fact, about two thirds of all woodfuels do not come from forests, but from agriculture and other land.
Mounting evidence shows that woodfuel use is not a general cause of deforestation. It is not even a main cause. Rather, deforestation is caused by land conversion and commercial logging in most places.
A cynic could say that deforestation is good news for woodfuel users, because they benefit twice. First, as long as deforestation goes on an abundance of wood residues becomes available for fuel. Second, when deforestation is completed most of the land is turned into plantations and agriculture, which provide more sustainable woodfuels per ha than forests do.

7. ESTIMATES OF WOOD ENERGY CONSUMPTION

Consumption of wood and food

7.1 Consumption Patterns

7.1.1 Woodfuel as a Commodity

Woodfuel is to a large extent non-commercialised. The largest single group of woodfuel consumers, farmers, are at the same time woodfuel producers. Furthermore, woodfuel consumption patterns are very site-specific. These are major reasons why the same market mechanisms which may apply to other commodities do not apply to wood energy.

7.1.2 Consumer Groups

Woodfuel consumers are diverse groups in the domestic sectors of rural and urban areas, as well as in the industrial and service sectors. Many domestic consumers are basically subsistence households, whereas others with more money mainly buy woodfuels from local markets.

7.1.3 Amounts Consumed

Woodfuel consumption levels vary per country and per region. National consumption per capita varies by as much as a factor of 5 over the RWEDP member-countries, depending on local conditions like climate, agro-ecological zone, culture and traditions, household income and size, accessibility of fuels, prices of fuels and devices, as well as options for substitution. Several conditions may change with land use practices and cropping patterns, economic changes, modernisation and urbanisation or other factors. Further, total national consumption depends on population and possibly GNP. Stated consumption data are sometimes under-estimated, because industrial consumption may not be included or household consumption is not fully recorded, or both.

7.2 Dynamics of Consumption

7.2.1 Consumer Options

In principle, all consumer groups avail themselves of a range of options to adapt their consumption pattern to changing conditions. For example, in response to reduced availability of fuelwood, a rural household could in principle:

- Consume less by adopting fuelwood saving practices
- Substitute fuelwood partly by other biomass fuels or fossil fuels
- Pay more at local markets
- Spend more time in collecting fuelwood for free from distant locations
- Harvest fuelwood non-sustainably from trees nearby
- Grow additional fuelwood in the homestead
- Grow (additional) trees on agricultural land
- Change cooking practices (diets) so that less fuel is required
- Adopt a combination of options and/or other solutions

This shows that the range of options is very diverse indeed.

Households which increase family incomes often switch from biomass fuels to other forms of energy like electricity and gas, which is known as 'stepping up the fuel ladder'. At the same time, new families frequently start at the lower end of the income and fuel ladder. However, many factors other than income can play a role with regard to household fuel use. If the new energy forms are not available or if the supply is not reliable, households may decide not to upgrade their fuel. Likewise, if woodfuel resources become scarce, people may downgrade to lower quality fuels. This illustrates that fuel switching is an extremely complex system, subject to many local factors.

7.2.2 Site-specificity

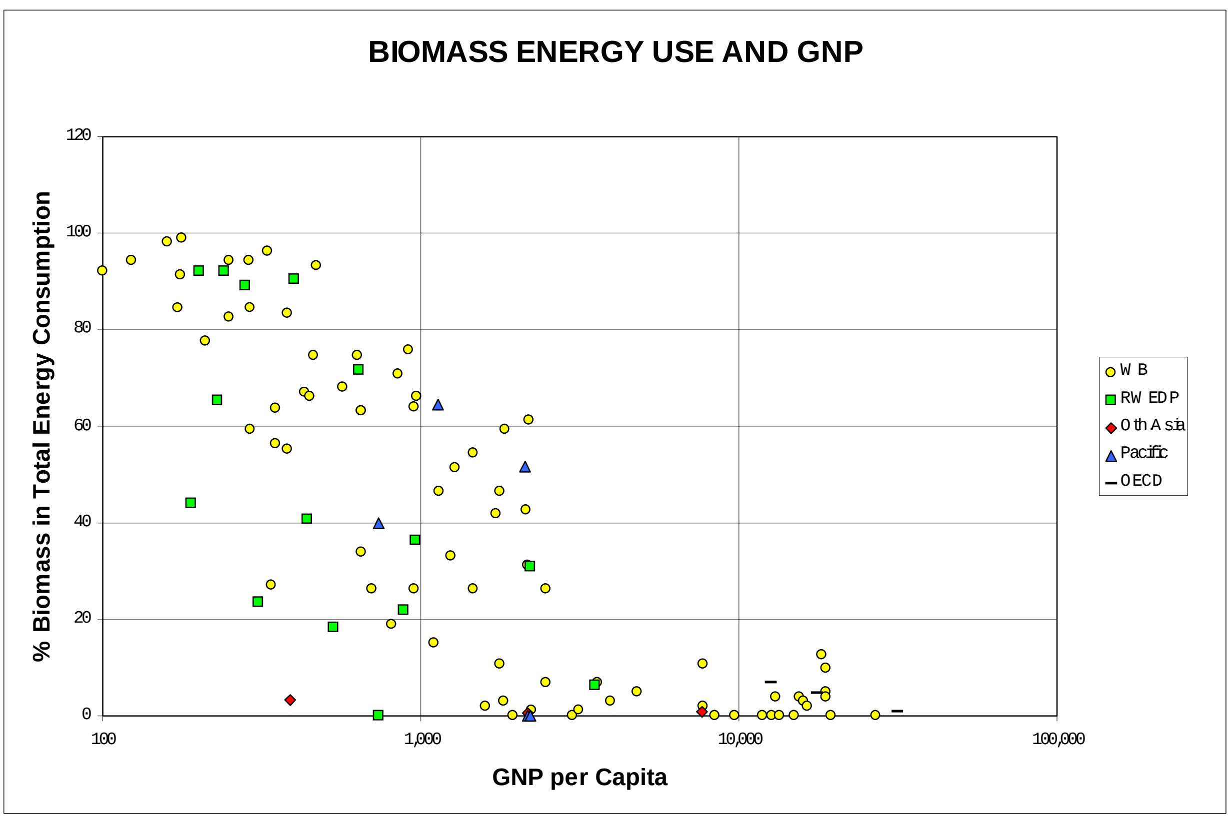
Case studies have shown that the actual response of consumer groups to changing conditions is very site-specific, varying per country and per region. A full set of reliable data on wood energy consumption and its dynamics is not available and can not be obtained without considerable efforts. Therefore, 'best estimates' of consumption have to be made.

7.2.3 Macro-level Factors: Population, GNP, Prices

When consumption per capita is subject to many unknown factors, population, at least, is a macro-level factor which influences national woodfuel consumption. The same may or may not be true for economic changes. With increase in average GNP per capita, changes in energy use take place. This often implies increase in energy use but also a shift from traditional to conventional sources of energy for part of the population, depending on income distribution characteristics. The net effect may be underlying Figure 5, which gives an overview of biomass energy use in relation to GNP per capita. The figure shows a general trend for biomass energy use to decline as GNP increases, but no relationship between incremental changes in the two variables can be deducted from the data. Apart from anecdotal data, income elasticities of woodfuel use are generally not known.

Prices of woodfuels depend on many factors and vary with local markets. Furthermore, a large proportion of woodfuels is non-monetized. Apart from anecdotal data, price elasticities of woodfuel consumption are generally not known.

Figure 5: Biomass energy use and GNP



7.3 Consumption Data

7.3.1 Databases

Data on wood energy consumption are published periodically by FAO, UN, WRI, IEA and AEEMTRC. Some of these sources make use of the data provided by the other organizations, and therefore are not independent. Data are also published by government departments. In some cases also data from national and international organizations may be 'recycled'. Furthermore, incidental data as based on specific surveys like World Bank/ESMAP and UNDP and others are published. Definitions used by the various organizations are in many cases not comparable and care should be taken to check what is meant when terms like woodfuel, fuelwood, residues, etc. are used.

7.3.2 Best Estimates

In order to determine the “best” estimate for woodfuel use in the Asia-Pacific region it would be preferable to use only one database system. Data within a single database system can then be assumed to have been treated in the same manner, both in terms of definitions and in terms of conversion factors from original units to energy units. Unfortunately, considering the large discrepancies between the numbers as well as lack of completeness, it is difficult to use one single database system for the Asia-Pacific region. Therefore, a combination of data from different database systems is used for the present study. Such a method has to be applied as long as no single database system is sufficiently complete to serve as a basis for all countries in the region.

For both RWEDP and OECD countries use is made of the data contained in the IEA database and/or country data. Exceptions are (for the time being) the following countries: Bhutan, India, Malaysia, the Philippines and Sri Lanka, as no data are available. For these countries the FAO/UN database system is used. For Asia-Other and the Pacific the data contained in the FAO/UN database system are used as the IEA database and/or country data are far from complete.

Table 7.1, at the end of this chapter, provides an overview of these “best” estimates[1] for the Asia-Pacific countries both for woodfuels as well as for biomass energy. Average annual changes have been calculated for the last 3-4 years for which data were available. Analysing the average annual increase over this period shows that increases have in general been moderate with a few exceptions, notably in Thailand as well as in Maldives, Fiji and Australia (biomass energy only in the latter).

The large increases in the Maldives as well as in Fiji are probably caused by the fact that no real time series are available (Maldives) and/or in the way estimates were made (Fiji). The reason for the sharp increases for Thailand and Australia can probably be traced back to the fact that in both countries efforts are being made to promote the use of renewable energy including biomass. Another factor which may play a role in the sharp increase, in particular in biomass energy for these countries as well as for Fiji, is increased sugar production resulting in

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[1] *“Best” estimates were identified in consultation with EDP-Asia who gave full access to their database. As EDP-Asia does not publish its data on a regular basis, full reference to the original sources is provided*

increases in bagasse use as a source of fuel. The same argument should also be valid for other sugar producing countries. Unfortunately, sufficient information is not available to substantiate this assumption.

7.4 Consumption Outlook

7.4.1 Projections

As many local conditions play a role in woodfuel consumption, it is not known to what extent each of the individual factors exerts an influence on the total national amount of energy used and on the choice of fuel. Projections are therefore generally based on simple extrapolations of historical trends. In order to explore the possibility of providing an alternative to these simple projections two exercises in computer modelling were carried out by RWEDP staff. One exercise is based on data published by the FAO (FAO, 1997b). The other exercise is based on the “best” estimates for woodfuel use presented in this paper. The results of both exercises are shown in Table 7.2 at the end of this chapter.

Exercise 1:

The first exercise used data drawn from Table III-2 (page 109) of an FAO publication(FAO, 1997b) to calculate the average annual growth rates of woodfuel consumption for the period 1994-2000 and 2000-2010. Many factors were taken into account, for example, economic growth rates, resources and population. However, for the Asia-Pacific region the validity of the base year, 1994, can be questioned as in all but one RWEDP member-country, China, the data are based on estimates made before 1961, and per capita woodfuel use was assumed constant since then. It should be noted that a systematic error as small as 2% per annum would lead to an error of 100% after 33 years. Such effects may explain the large discrepancies between the results of the modelling and other studies (including the “best” estimates reported here) regarding e.g. Bangladesh, China, Indonesia, Malaysia, Myanmar, Pakistan and Vietnam. For Pakistan the extensive World Bank/ESMAP and UNDP survey in 1991 found 1.7 times more woodfuel consumption in the household sector alone, than FAO statistics report.

Exercise 2:

The second exercise is again based on the “best” estimates. The inputs used are as far as possible based on the most recently available data from national sources which are considered reliable regarding both level of consumption and growth rate. Woodfuel consumption growth rates for the period 1994-2000 were (arbitrarily) assumed to remain the same as were calculated for the period 1992-1994. For the period 2000-2010 the growth rates were reduced (again arbitrarily) by assuming that the reduction in the growth rates as shown in exercise 1 would also be valid for the second exercise.

Comparison of the Results of the Exercises

Table 7.2 shows that the difference between the results using the FAO data (Exercise 1) and the “best” estimates data (Exercise 2) is about 170 million cubic metres (20%) in 1994 (about 850 million cum. versus 1020 million cum.) aggregated for the Asia-Pacific countries listed. The difference would rise to about 260 million cum. (25%) in the year 2010 (1020 million cum.

versus 1280 million cum.). For individual countries the differences for the baseline year (1994) can be as large as 200% (Bangladesh, Myanmar, Pakistan, Thailand) or even 5,000% (New Zealand). Combined with different growth rates applied, such differences can amplify to almost 300% (Thailand) in the year 2010.

These results illustrate the need for updating and harmonising databases. At present detailed modelling appears to be of little value as long as large discrepancies in data exist. Thus, for the time being, RWEDP will carry on with the "best" estimates as presented here. In the meantime, the main message which can be derived from either exercise is that woodfuel use will continue and will even grow. But, its share in overall energy consumption will decline.

Business as Usual

Very superficial calculations, using business-as-usual projections made by UN-ESCAP for conventional energy use (ESCAP, 1997) show that in 1994 woodfuels accounted for about 8.2% to 9.8% of total energy consumption (total energy consumption here refers to conventional energy and woodfuels and excludes biomass energy). In the year 2010 the share of woodfuels will have dropped to about 4.6 to 5.7% depending on which scenario for woodfuel projection is used. These calculations were not used for the present paper.

Table 7.1. - Best estimate with regard to woodfuel and biomass energy use in the Asia-Pacific region

WOODFUEL AND BIOMASS/RENEWABLE ENERGY CONSUMPTION IN PJ												
		Best Estimate Woodfuels				Annual change in % Woodfuels	Biomass / Combustible renewables				Annual change in % Biomass	Source - Remarks
		1992	1993	1994	1995		1992	1993	1994	1995		
	ASIA-RWEDP											
1	Bangladesh	115.0			149.0	5.32	504.0			568.0	2.42	EDP-Asia 1990 data used for 1992
2	Bhutan	12.7	12.8	12.9	13.2	1.46						FAO / UN
3	Cambodia			80.7	78.0	-3.35			87.8	83.0	-5.47	EDP-Asia
4	China	3,281.0		3,290.0		0.14	7,337.5	7,360.8	7,389.7		0.36	EDP-Asia
5	India	2,507.2	2,555.3	2,603.4	2,676.7	2.20	2,881.5	2,876.7	2,929.1		0.82	FAO / UN
6	Indonesia	787.3	797.0	817.9		1.92	787.3	797.0	817.9		1.92	EDP-Asia
7	Laos	40.0	41.1	42.4		2.97						FAO / UN
8	Malaysia	88.6	90.7	92.9	95.8	2.64	91.1	93.3	95.5		2.39	FAO / UN
9	Maldives	1.1		1.2		7.20	1.1		1.2		7.20	EDP-Asia
10	Myanmar	343.8	345.0			0.35	343.8	345.0			0.35	EDP-Asia
11	Nepal	180.6	183.9	192.0	196.0	2.77	240.4	246.2	256.1	262.0	2.91	EDP-Asia
12	Pakistan			520.8				911.0	918.2		0.80	EDP-Asia
13	Philippines	331.8	339.0	346.1	356.6	2.43	387.3					FAO / UN
14	Sri Lanka	83.2	84.2	85.3	87.1	1.52	89.4	92.2	95.0		3.06	FAO / UN
15	Thailand	588.8	647.0	691.7	703.0	6.08	693.9	755.7	825.9	870.0	7.82	EDP-Asia
16	Vietnam	423.0				1.21	815.8					EDP-Asia (increase based on 1990-1992)
	ASIA-OTHER											
17	Iran, Islamic Rep	24.4	24.5	24.7	25.0	0.85					---	FAO / UN
18	Korea DPR	40.5	40.9	41.4	42.2	1.41					---	FAO / UN
19	Korea Rep.	43.4	43.4	43.4	43.8	0.30	43.9	43.9	43.9		0.00	FAO / UN
20	Mongolia	3.5	3.6	3.6	3.7	1.67					---	FAO / UN
	PACIFIC											
21	Cook Islands										---	FAO / UN
22	Fiji	0.4	0.4	0.4	0.4	0.30	11.7	11.7	14.0		9.41	FAO / UN
23	Papua New Guinea	53.5	53.5	53.5	54.0	0.30	59.7	59.7	59.8		0.10	FAO / UN
24	Samoa	0.7	0.7	0.7	0.7	0.30					---	FAO / UN
25	Solomon Island	1.3	1.3	1.3	1.3	0.30	3.2				---	FAO / UN
26	Tonga										---	FAO / UN
27	Vanuatu	0.2	0.2	0.2	0.2	0.30					---	FAO / UN
	OECD Members											
28	Australia	90.4	92.9	93.4		1.69	164.5	181.7	188.8		7.13	IEA / EDP-Asia
29	Japan		153.5	150.5		-1.95		184.6	181.3		-1.81	IEA
30	New Zealand	26.1	27.5	27.5		2.65	41.0	42.7	42.7		2.02	IEA / EDP-Asia

Table 7.2. Sample projections for woodfuel use for the period 1994-2010

Country groupings	FAO - Global Forest Products Outlook to 2010 Projected Fuelwood Consumption: Fuelwood consumption in '000 Cum. per year			FAO: Average annual Growth rate %		RWEDP - EDP-Asia Projected Woodfuel Consumption 1994 - 2010: Average annual growth rate		Projected annual growth rate	RWEDP: Fuelwood consumption in '000 Cum. per year		
	1994	2000	2010	1994/2000	2000/2010	1980/1994	1992/1994	2000/2010	1994	2000	2010
RWEDP											
Bangladesh	30,620	32,356	35,012	0.92	0.79	4.18	5.32	4.57	14,455	19,728	30,829
Bhutan							1.46		1,260	1,375	1,375
Cambodia	6,454	7,047	7,790	1.48	1.01	-3.35	-3.35	-2.29	8,269	6,740	5,348
China	204,094	227,209	255,839	1.80	1.19	-2.64	0.14	0.09	337,110	339,951	343,115
India	256,485	275,270	302,387	1.18	0.94	2.07	2.20	1.75	266,788	303,999	361,705
Indonesia	147,033	163,319	180,146	1.77	0.99	2.55	1.92	1.07	83,806	93,936	104,503
Laos	3,583	3,878	4,278	1.33	0.99	2.75	2.97	2.21	4,342	5,176	6,440
Maldives							7.20	5.40	123	187	316
Malaysia	6,845	7,585	8,523	1.72	1.17	2.59	2.54	1.73	9,519	11,065	13,131
Myanmar	19,331	21,050	23,227	1.43	0.99	0.99	0.35	0.24	35,474	36,226	37,113
Nepal	19,500	20,819	22,647	1.10	0.85	2.23	2.77	2.14	19,673	23,178	28,631
Pakistan	26,700	28,413	31,076	1.04	0.90		1.04	0.90	53,364	56,781	62,096
Philippines	35,170	37,245	40,635	0.96	0.87	2.26	2.43	2.22	35,463	40,958	50,993
Sri Lanka	8,779	9,442	10,339	1.22	0.91	1.29	1.52	1.14	8,740	9,568	10,712
Thailand	32,318	35,505	39,735	1.58	1.13	7.51	6.08	4.36	70,875	100,994	154,723
Vietnam	29,761	32,968	37,030	1.72	1.17	1.21	1.21	0.82	45,182	48,563	52,708
Oth.Asia											
Iran, Islamic Rep	1,997	2,103	2,253	0.87	0.69	0.92	0.85	0.68	2,531	2,663	2,849
Korea DPR	4,276	4,497	4,854	0.84	0.77	0.93	1.41	1.28	4,242	4,614	5,241
Korea Rep.	4,678	5,176	5,801	1.70	1.15	-2.69	0.3	0.20	4,447	4,528	4,620
Mongolia	376	395	427	0.82	0.78	-8.07	1.67	1.58	369	407	477
Pacific											
Fiji	37	38	41	0.45	0.76		0.3	0.51	41	42	44
Papua New Guinea	5,533	5,714	6,008	0.54	0.50	0.27	0.3	0.28	5,482	5,581	5,740
Samoa	70	74	80	0.93	0.78		0.3	0.25	72	73	75
Solomon Islands	138	139	144	0.12	0.35		0.3	0.88	133	136	148
Vanuatu	24	25	26	0.68	0.39		0.3	0.17	20	21	21
OECD											
Australia	2,696	2,170	1,629	-3.55	-2.83	2.36	1.69	1.35	9,570	10,583	12,096
Japan	431	361	270	-2.91	-2.86	-1.95	-1.95	-1.92	0	0	0
New Zealand	50	38	28	-4.47	-3.01	2.23	2.65	1.78	2,818	3,297	3,934
Total '000 Cum. for region	**846,979**	**922,836**	**1,020,225**	**1.44**	**1.01**		**1.66**	**1.40**	**1,024,170**	**1,130,369**	**1,298,981**

Data in grey are based upon FAO data (production in the past)

8. SUPPLY & CONSUMPTION OUTLOOK

Whatever woodfuel is being consumed must have been produced. This is the principle used to derive woodfuel supply data, with a few notable exceptions. As a result, independent data on supply is rarely available, and planning for balancing supply-demand non-existent. The situation can be compared with fossil fuels or electricity, where real supply data are available. Future supply requirements are governed by demand forecasts based on present consumption data. The fine-tuning of demand forecasts allows for more accurate supply planning.

By contrast, the fine-tuning of woodfuel demand forecasts remains an academic exercise, as long as data on present and future woodfuel supplies are not available. How can this situation be improved? RWEDP has attempted to estimate present and future potential woodfuel supplies. To do this, use was made of the best estimates given in Chapter 7, and some crucial assumptions had to be made. These assumptions show which supplementary information on woodfuel supplies needs to be collected in order to make demand forecasting a reasonable exercise.

For the time being, the results help to identify broad policy issues. However, it should be emphasised that national aggregate data still bear little meaning as they hide local variations. Ultimately, supply and demand information should be area-based.

8.1 Country Balances

The balances below give an overview of the woodfuel consumption and the potential supply from forest and non-forest resources, for the whole region and for each country. Although partly based on assumptions regarding future trends and natural resources productivity , it can be concluded that for the region as a whole and for most countries, the potential supply can meet the aggregated consumption. For some countries there appears to be a gap between supply and consumption (Bangladesh, Nepal, Pakistan). But the imbalances may appear due to data inaccuracy and/or overly conservative assumptions regarding supply. Nevertheless, these countries may need special attention with respect to wood energy. This also applies to India, Sri Lanka, Thailand, and Vietnam, which may face a critical situation sometime after the year 2010.

It should be emphasised that the balances are based on aggregated national data, which can hide local variations, ranging from scarcity to abundance.

Woodfuel consumption figures are based on best estimates obtained from various data sources. Potential supply figures are based on data, estimates and projections for land use, wood productivity for several land use classes, and the availability of wood for energy use. FAO publications were used as source data for land use and wood productivity. For forest land, other wooded land and agriculture areas, the potential supply is based on average annual yield estimates, assuming a sustainable use of resources. Wood waste from deforestation refers to wood potentially available from natural forest land cleared due to commercial logging, expansion of agriculture land or other reasons.

Woodfuel balances are given for 1994 (current situation) and 2010 (projected situation). Woodfuel consumption and production are given in mass units (kton) and energy units (petajoules).

RWEDP Region

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**645,895**	**9,688**		**811,548**	**12,173**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	416,204	669,812	10,047	370,363	629,339	9,440
sust. woodfuel from agricultural areas	876,933	601,407	9,021	971,062	692,088	10,381
sust. woodfuel from other wooded lands	93,140	53,994	810	81,368	47,170	708
waste woodfuels from deforestation	(4,253)	605,565	9,083	(3,114)	437,710	6,566
total potentially available woodfuels*	**1,382,024**	**1,930,778**	**28,962**	**1,419,679**	**1,806,307**	**27,095**
50% of crop processing residues	876,933	218,915	3,458	971,062	322,024	5,105
total potentially available biomass fuels		**2,149,693**	**32,420**		**2,128,331**	**32,200**

* *Area = 77% of geographical land area*

Bangladesh

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**9,396**	**141**		**13,320**	**200**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	1,009	1,765	26	1,066	2,416	36
sust. woodfuel from agricultural areas	9,398	5,593	84	9,418	5,636	85
sust. woodfuel from other wooded lands	370	215	3	350	203	3
waste woodfuels from deforestation	(14)	1,426	21	(10)	1,016	15
total potentially available woodfuels*	**10,763**	**8,999**	**135**	**10,824**	**9,271**	**139**
50% of crop processing residues	9,398	5,604	88	9,418	6,234	98
total potentially available biomass fuels		**14,602**	**223**		**15,505**	**237**

* *Area = 83% of geographical land area*

Bhutan

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**819**	**12**		**1,195**	**18**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	2,767	3,822	57	2,593	3,611	54
sust. woodfuel from agricultural areas	413	239	4	443	257	4
sust. woodfuel from other wooded lands	355	206	3	355	206	3
waste woodfuels from deforestation	(12)	1,678	25	(11)	1,551	23
total potentially available woodfuels*	**3,523**	**5,946**	**89**	**3,380**	**5,624**	**84**
50% of crop processing residues	413	19	0	443	5	0
total potentially available biomass fuels		**5,965**	**89**		**5,629**	**84**

Area = 75% of geographical land area

Cambodia

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**5,375**	**81**		**7,553**	**113**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	10,298	14,029	210	5,377	7,705	116
sust. woodfuel from agricultural areas	5,459	3,394	51	9,776	6,056	91
sust. woodfuel from other wooded lands	1,433	831	12	1,351	783	12
waste woodfuels from deforestation	(468)	63,311	950	(216)	29,283	439
total potentially available woodfuels*	**16,722**	**81,565**	**1,223**	**16,288**	**43,827**	**657**
50% of crop processing residues	5,459	457	7	9,776	358	5
total potentially available biomass fuels		**82,022**	**1,231**		**44,185**	**663**

* *Area = 95% of geographical land area*

China

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**219,122**	**3,287**		**252,819**	**3,792**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	133,418	235,541	3,533	132,265	248,605	3,729
sust. woodfuel from agricultural areas	496,486	288,700	4,331	551,575	322,072	4,831
sust. woodfuel from other wooded lands	27,526	15,957	239	26,894	15,591	234
waste woodfuels from deforestation	(489)	58,347	875	(448)	53,465	802
total potentially available woodfuels*	**656,941**	**598,546**	**8,978**	**710,286**	**639,733**	**9,596**
50% of crop processing residues	496,486	78,003	1,169	551,575	115,445	1,718
total potentially available biomass fuels		**676,549**	**10,148**		**755,178**	**11,314**

* *Area = 70% of geographical land area*

India

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**173,412**	**2,601**		**225,725**	**3,386**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	64,996	85,695	1,285	65,363	98,313	1,475
sust. woodfuel from agricultural areas	189,805	125,323	1,880	195,235	138,132	2,072
sust. woodfuel from other wooded lands	8,884	5,150	77	3,454	2,002	30
waste woodfuels from deforestation	(269)	18,999	285	(244)	17,280	259
total potentially available woodfuels*	**263,416**	**235,167**	**3,528**	**263,808**	**255,729**	**3,836**
50% of crop processing residues	189,805	70,267	1,143	195,235	106,319	1,759
total potentially available biomass fuels		**305,434**	**4,670**		**362,048**	**5,594**

* *Area = 89% of geographical land area*

Indonesia

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**54,474**	**817**		**67,465**	**1,012**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	110,968	183,106	2,747	94,100	157,282	2,359
sust. woodfuel from agricultural areas	59,893	67,744	1,016	72,316	84,813	1,272
sust. woodfuel from other wooded lands	11,512	6,673	100	6,960	4,035	61
waste woodfuels from deforestation	(1,177)	181,526	2,723	(964)	148,794	2,232
total potentially available woodfuels*	**181,196**	**439,049**	**6,586**	**172,411**	**394,923**	**5,924**
50% of crop processing residues	59,893	20,421	327	72,316	28,938	457
total potentially available biomass fuels		**459,470**	**6,912**		**423,861**	**6,381**

* *Area = 100% of geographical land area*

Laos

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**2,329**	**35**		**3,496**	**52**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	12,583	18,472	277	10,468	15,396	231
sust. woodfuel from agricultural areas	1,700	979	15	1,844	1,054	16
sust. woodfuel from other wooded lands	8,259	4,788	72	8,259	4,788	72
waste woodfuels from deforestation	(148)	21,767	327	(120)	17,665	265
total potentially available woodfuels*	**22,394**	**46,006**	**690**	**20,450**	**38,902**	**584**
50% of crop processing residues	1,700	343	5	1,844	333	5
total potentially available biomass fuels		**46,349**	**695**		**39,235**	**589**

* *Area = 97% of geographical land area*

Malaysia

	1994			2010		
	Area	Mass	Energy	Area	Mass	Energy
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**6,187**	**93**		**8,216**	**123**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	15,910	31,737	476	10,543	21,324	320
sust. woodfuel from agricultural areas	12,652	17,809	267	16,928	22,409	336
sust. woodfuel from other wooded lands	-	-	-	-	-	-
waste woodfuels from deforestation	(442)	87,754	1,316	(272)	54,044	811
total potentially available woodfuels*	**28,120**	**137,301**	**2,060**	**27,199**	**97,777**	**1,467**
50% of crop processing residues	12,652	2,470	32	16,928	3,934	49
total potentially available biomass fuels		**139,771**	**2,092**		**101,712**	**1,515**

* *Area = 85% of geographical land area*

Maldives

	1994			2010		
	Area	Mass	Energy	Area	Mass	Energy
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**80**	**1**		**123**	**2**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	-	-	-	-	-	-
sust. woodfuel from agricultural areas	18	34	1	21	41	1
sust. woodfuel from other wooded lands	-	-	-	-	-	-
waste woodfuels from deforestation	-	-	-	-	-	-
total potentially available woodfuels*	**18**	**34**	**1**	**21**	**41**	**1**
50% of crop processing residues	18	4	0	21	4	0
total potentially available biomass fuels		**38**	**1**		**46**	**1**

* *Area = 13% of geographical land area*

Myanmar

	1994			2010		
	Area	Mass	Energy	Area	Mass	Energy
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**23,058**	**346**		**31,183**	**468**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	27,539	45,928	689	22,166	37,389	561
sust. woodfuel from agricultural areas	10,779	6,884	103	10,946	7,284	109
sust. woodfuel from other wooded lands	20,325	11,782	177	20,158	11,686	175
waste woodfuels from deforestation	(396)	65,341	980	(307)	50,571	759
total potentially available woodfuels*	**58,247**	**129,935**	**1,949**	**52,964**	**106,930**	**1,604**
50% of crop processing residues	10,779	4,350	66	10,946	5,563	84
total potentially available biomass fuels		**134,285**	**2,015**		**112,493**	**1,688**

* *Area = 89% of geographical land area*

Nepal

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**12,787**	**192**		**18,378**	**276**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	4,873	4,188	63	4,133	3,586	54
sust. woodfuel from agricultural areas	4,500	2,608	39	4,838	2,804	42
sust. woodfuel from other wooded lands	672	390	6	672	390	6
waste woodfuels from deforestation	(51)	4,258	64	(43)	3,524	53
total potentially available woodfuels*	**9,994**	**11,444**	**172**	**9,600**	**10,304**	**155**
50% of crop processing residues	4,500	1,021	16	4,838	1,354	22
total potentially available biomass fuels		**12,465**	**188**		**11,657**	**176**

* *Area = 70% of geographical land area*

Pakistan

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**34,687**	**520**		**52,167**	**783**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	1,803	1,960	29	1,162	1,461	22
sust. woodfuel from agricultural areas	26,511	15,371	231	28,399	16,465	247
sust. woodfuel from other wooded lands	1,104	640	10	1,104	640	10
waste woodfuels from deforestation	(55)	4,598	69	(31)	2,578	39
total potentially available woodfuels*	**29,363**	**22,569**	**339**	**30,634**	**21,144**	**317**
50% of crop processing residues	26,511	7,806	137	28,399	12,092	212
total potentially available biomass fuels		**30,375**	**475**		**33,236**	**530**

* *Area = 38% of geographical land area*

Philippines

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**23,051**	**346**		**30,329**	**455**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	7,020	12,962	194	4,154	7,941	119
sust. woodfuel from agricultural areas	21,153	30,819	462	25,409	39,177	588
sust. woodfuel from other wooded lands	-	-	-	-	-	-
waste woodfuels from deforestation	(254)	45,486	682	(134)	24,052	361
total potentially available woodfuels*	**27,919**	**89,267**	**1,339**	**29,429**	**71,171**	**1,068**
50% of crop processing residues	21,153	9,821	169	25,409	11,535	198
total potentially available biomass fuels		**99,088**	**1,508**		**82,706**	**1,266**

* *Area = 78% of geographical land area*

Sri Lanka

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**5,681**	**85**		**6,769**	**102**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	1,814	1,923	29	1,557	1,706	26
sust. woodfuel from agricultural areas	4,025	5,273	79	4,357	6,015	90
sust. woodfuel from other wooded lands	411	239	4	98	57	1
waste woodfuels from deforestation	(18)	1,529	23	(15)	1,266	19
total potentially available woodfuels*	**6,232**	**8,963**	**134**	**5,998**	**9,044**	**136**
50% of crop processing residues	4,025	1,114	19	4,357	1,389	24
total potentially available biomass fuels		**10,076**	**153**		**10,433**	**159**

* *Area = 97% of geographical land area*

Thailand

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**46,069**	**691**		**53,390**	**801**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	11,957	12,741	191	7,970	9,133	137
sust. woodfuel from agricultural areas	25,627	23,243	349	30,185	31,101	467
sust. woodfuel from other wooded lands	-	-	-	-	-	-
waste woodfuels from deforestation	(327)	31,046	466	(199)	18,923	284
total potentially available woodfuels*	**37,257**	**67,030**	**1,005**	**37,956**	**59,157**	**887**
50% of crop processing residues	25,627	10,863	181	30,185	18,393	317
total potentially available biomass fuels		**77,893**	**1,186**		**77,550**	**1,204**

* *Area = 68% of geographical land area*

Vietnam

	1994			2010		
	Area	**Mass**	**Energy**	**Area**	**Mass**	**Energy**
CONSUMPTION	*1000 ha*	*kton*	*PJ*	*1000 ha*	*kton*	*PJ*
total woodfuels		**29,368**	**441**		**39,418**	**591**
POTENTIAL SUPPLY						
sust. woodfuel from forest land	9,250	15,943	239	7,447	13,471	202
sust. woodfuel from agricultural areas	8,515	7,396	111	9,372	8,772	132
sust. woodfuel from other wooded lands	12,288	7,124	107	11,713	6,790	102
waste woodfuels from deforestation	(133)	18,498	277	(98)	13,697	205
total potentially available woodfuels*	**29,920**	**48,960**	**734**	**28,433**	**42,730**	**641**
50% of crop processing residues	8,515	6,352	99	9,372	10,128	157
total potentially available biomass fuels		**55,312**	**834**		**52,858**	**798**

* *Area = 92% of geographical land area*

8.2 Notes on the Detailed Woodfuel Tables

These notes help to clarify the methods, data and assumptions used for the evaluation and projection of consumption and potential supply of woodfuels (see detailed tables below).

Land Use

Land use data for 1990 (row 1-4) was obtained from FAO Forest Resources Assessment 1990 (FAO, 1993), for 1995 (row 5-6) from "State of the World's Forests" (FAO, 1997a). Land use data for 1994 was required because data on woodfuel consumption are available only up to 1994. Since these were not available, they were obtained (see row 7-9) by interpolation of the 1990 and 1995 data, assuming a constant annual growth rate during the 5 year interval.

Since data on the area under other wooded land in 1995 were not available, it was assumed constant (row 4, 10). The area under coconut, rubber and oil palm plantations (row 11) was distinguished because data and wood production could be derived from specific data on crop production, productivity and residue-to-product ratios.

Row 13-18 give the average annual change of land use in absolute terms and growth rates. The natural forest area (row 19) for the year 2010 was projected by assuming the same average annual growth rate as during 1990-95 (row 16). The area of plantations was projected by assuming the same average annual increase in hectares as during 1990-95 (row 14). As in 1994, the area of other wooded land (row 23) was assumed constant, and the area of coconut, rubber and oil palm plantations (row 24) was obtained from projected production figures.

Wood Production

Data on wood productivity of natural forest was derived from FAO data on biomass density for natural forest per country (FAO, 1993), assuming an average annual yield of 1% of the biomass density (excluding leaves, see row 27-29). For plantations and other wooded land a constant figure was assumed for all countries, based on various sources (row 30-31).

Not all wood from the resources will be available as fuel, so assumptions were made on the percentage of wood for fuel (80% for all land use types, see row 32-35).

Rows 36-43 show the potential supply of woodfuel from the various land use types for 1994 and 2010, given the data used and the assumptions on land use, productivity and availability.

Wood from Agricultural Lands

Data on the agricultural area for 1984 and 1994 (row 44-45) were obtained from FAO statistics (FAO, 1995b). The agricultural area for 2010 was projected assuming that the area will remain constant in the case of a decrease during 1984-94, and otherwise that it will increase with the same average annual increase as during 1984-94 (row 46).

The area under coffee, tea and cocoa was distinguished because the wood production for these land use types could be derived from data on crop production, productivity and residue-to-product ratios. As for wood from forest and wood land, assumptions were made on the productivity and the availability of wood for fuel (row 53-54).

Rows 55-58 show the potential supply of woodfuel from agricultural land for 1994 and 2010, given the data used and the assumptions on land use, productivity and availability.

The woodfuel supply evaluation only considers forests, other wooded land and agriculture land. Since these may not comprise the whole geographical area of a country, and other land use types may also supply wood, there may exist an additional potential or hidden supply of (fuel)wood (row 59-61).

Rows 62-67 give an overview of the potential fuelwood supply for the various land use types in kiloton per year. Rows 68-73 give the same in petajoules per year. The corresponding figures for the year 2010 are given in rows 82-87 and rows 88-93, respectively.

Fuelwood Consumption

Data on fuelwood consumption were adopted from the best estimates available to RWEDP, from various data sources (row 79). For those countries for which data on sources of fuelwood were available, i.e. the share of fuelwood from forests (row 76), the data were used to estimate the origin of the consumed fuelwood. For those countries for which such data were not available a regional average of 32% coming from forest areas was applied.

Fuelwood consumption in the year 2010 (row 95) was projected by assuming a correlation of 1 to 1 between population growth and fuelwood consumption. Population projections for all countries were available from the World Resources Institute (row 94).

Potential Woodfuel Production and Requirements in 1994 and 2010

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
	Wood from Forest and Other Wooded Land																			
1	1990 natural forest area	*FAO 90*	*1000 ha*	769	2,809	12,163	101,968	51,729	109,549	13,173	17,583		28,856	5,023	1,855	7,831	1,746	12,735	8,312	376,101
2	1990 plantation area	*FAO 90*	*1000 ha*	235	4	7	31,831	13,230	6,125	4	81		235	56	168	203	139	529	1,470	54,317
3	1990 total forest area	*FAO 90*	*1000 ha*	1,004	2,813	12,170	133,799	64,959	115,674	13,177	17,664	-	29,091	5,079	2,023	8,034	1,885	13,264	9,782	430,418
4	1990 other wooded land	*FAO 90*	*1000 ha*	468	355	1,554	28,230	17,689	29,434	8,259	4,584		20,683	672	1,105	5,606	2,113	1,704	13,717	136,173
5	1995 natural forest area	*FAO 97*	*1000 ha*	700	2,748	9,823	99,523	50,385	103,666	12,431	15,371		26,875	4,766	1,580	6,563	1,657	11,101	7,647	354,836
6	1995 total forest area	*FAO 97*	*1000 ha*	1,010	2,756	9,830	133,323	65,005	109,791	12,435	15,471		27,151	4,822	1,748	6,766	1,796	11,630	9,117	412,651
7	1994 natural forest area	*in.*	*1000 ha*	713	2,760	10,252	100,007	50,651	104,817	12,576	15,790	-	27,260	4,816	1,632	6,799	1,674	11,410	7,776	358,933
8	1994 plantation area	*d.*	*1000 ha*	296	7	46	33,411	14,345	6,151	7	120	-	279	57	171	221	139	547	1,474	57,271
9	1994 total forest area	*in.*	*1000 ha*	1,009	2,767	10,298	133,418	64,996	110,968	12,583	15,910	-	27,539	4,873	1,803	7,020	1,814	11,957	9,250	416,204
10	1994 other wooded land	*FAO 90*	*1000 ha*	468	355	1,554	28,230	17,689	29,434	8,259	4,584		20,683	672	1,105	5,606	2,113	1,704	13,717	136,173
11	of which rubber, coconut, palm oil	*es.*	*1000 ha*	98	-	121	704	8,805	17,922	-	4,767	14	358	-	1	10,503	1,702	4,382	1,429	50,805
12	1994 other land than rubber, coconut, palm oi	*es.*	*1000 ha*	370	355	1,433	27,526	8,884	11,512	8,259	-	-	20,325	672	1,104	-	411	-	12,288	93,140
	Change of Area																			
13	av. an. change in natural forest area	*d.*	*1000 ha/y*	(14)	(12)	(468)	(489)	(269)	(1,177)	(148)	(442)	-	(396)	(51)	(55)	(254)	(18)	(327)	(133)	(4,253)
14	av. an. change in plantation area	*d.*	*1000 ha/y*	15	1	10	395	279	6	1	10	-	11	0	1	4	0	4	1	739
15	av. an. change in total forest area	*d.*	*1000 ha/y*	1	(11)	(468)	(95)	9	(1,177)	(148)	(439)	-	(388)	(51)	(55)	(254)	(18)	(327)	(133)	(3,553)
16	Av. an. growth rate of natural forest	*d.*	*percent*	(1.9)	(0.4)	(4.2)	(0.5)	(0.5)	(1.1)	(1.2)	(2.7)		(1.4)	(1.0)	(3.2)	(3.5)	(1.0)	(2.7)	(1.7)	(1.2)
17	Av. an. growth rate of plantation area	*d.*	*percent*	5.9	16.3	60.2	1.2	2.0	0.1	16.7	10.2		4.4	0.5	0.5	2.1	0.1	0.8	0.1	1.3
18	Av. an. growth rate of total forest area	*d.*	*percent*	0.1	(0.4)	(4.2)	(0.1)	0.0	(1.0)	(1.2)	(2.6)		(1.4)	(1.0)	(2.9)	(3.4)	(1.0)	(2.6)	(1.4)	(0.8)

*Land use data available for 1990 and 1995 (FAO 1993, FAO 1997a). Land use in 1994 estimated because consumption data available up to 1994. Natural forest area in 1994 estimated by assuming a constant deforestation rate between 1990 and 1995. Plantation area in 1994 estimated by assuming a constant average annual increase between 1990 and 1995 (area in 1994 = area90 + {{area95-area90}*4/5}) Plantation area in 1995 derived by total area minus natural forest area. Area of other wooded land assumed constant. Area for rubber, coconut and palm oil estimated from production and productivity.*

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
	Projection for Forest Area																			
19	2010 natural forest area	*ex.*	*1000 ha*	528	2,573	5,174	92,534	46,559	87,846	10,446	10,269	-	21,711	4,071	976	3,863	1,416	7,353	5,955	301,275
20	Area deforested in 2010	*ex.*	*1000 ha*	(10)	(11)	(216)	(448)	(244)	(964)	(120)	(272)	-	(307)	(43)	(31)	(134)	(15)	(199)	(98)	(3,114)
21	2010 plantation area	*ex.*	*1000 ha*	538	21	203	39,731	18,804	6,254	21	274	-	455	61	185	291	141	617	1,492	69,088
22	2010 total forest area	*ex.*	*1000 ha*	1,066	2,593	5,377	132,265	65,363	94,100	10,468	10,543	-	22,166	4,133	1,162	4,154	1,557	7,970	7,447	370,363
23	2010 other wooded land	*ex.*	*1000 ha*	468	355	1,554	28,230	17,689	29,434	8,259	4,584		20,683	672	1,105	5,606	2,113	1,704	13,717	136,173
24	of which rubber, coconut, palm oil	*ex.*	*1000 ha*	118	-	203	1,336	14,235	22,474	-	5,331	17	525	-	1	13,815	2,015	7,030	2,004	69,104
25	2010 other land than rubber, coconut, palm oi	*ex.*	*1000 ha*	350	355	1,351	26,894	3,454	6,960	8,259	-	-	20,158	672	1,104	-	98	-	11,713	81,368

Land use projections are based on the assumption of constant deforestation rates for natural forest and a constant annual increase of plantation area. Other wooded land was assumed to be constant.

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
	Productivity																			
26	Natural forest standing stock (stem volume)	*FAO 90*	*m3/ha*	77	150	122	96	47	179	128	214		145	55	87	182	45	62	119	125
27	Biomass in Natural Forest (incl. leaves)	*FAO 90*	*ton/ha*	136	181	178	157	93	203	193	261		217	109	110	236	113	125	183	173
28	Biomass in Nat. For. (excl. leaves = -5%)	*es.*	*ton/ha*	129	172	169	149	88	193	183	248	-	206	104	105	224	107	119	174	164
29	Biomass Annual Increment	*es.*	*ton/ha/yr*	1.3	1.7	1.7	1.5	0.9	1.9	1.8	2.5	-	2.1	1.0	1.0	2.2	1.1	1.2	1.7	1.6
30	Plantation productivity	*as.*	*m3/ha/y*	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
31	Other wooded lands productivity	*as.*	*m3/ha/y*	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Biomass density data available by country from FAO Forest Resources Assessment 1990 (FAO, 1993). Leaves assumed to be 5% of total biomass, subtracted because not woody biomass. Annual increment assumed to be 1.0% of biomass density, based on FAO figures on stock and increment in Asia.

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
32	availability for fuel from natural forests	*as.*	*percent*	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
33	availability for fuel from plantations	*as.*	*percent*	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
34	availability for fuel from other wooded lands	*as.*	*percent*	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
35	availability for fuel from wood waste	*as.*	*percent*	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
Production																				
36	1994 sust. production from natural forests	*d.*	*kton/yr*	737	3,797	13,869	119,329	35,800	161,711	18,446	31,321	-	44,957	3,990	1,364	12,195	1,438	10,840	10,814	470,608
37	1994 production from wood waste	*d.*	*kton/yr*	1,426	1,678	63,311	58,347	18,999	181,526	21,767	87,754	-	65,341	4,258	4,598	45,486	1,529	31,046	18,498	605,565
38	1994 production from plantations	*d.*	*kton/yr*	1,028	25	160	116,212	49,895	21,394	26	416	-	970	199	596	767	485	1,902	5,128	199,204
39	1994 production from other wooded lands (no rubber, coconut, palm oil)	*d.*	*kton/yr*	215	206	831	15,957	5,150	6,673	4,788	-	-	11,782	390	640	-	239	-	7,124	53,994
40	2010 sust. production from natural forests	*d.*	*kton/yr*	546	3,539	7,000	110,412	32,908	135,528	15,323	20,370	-	35,806	3,373	816	6,929	1,216	6,985	8,282	389,032
41	2010 production from wood waste	*d.*	*kton/yr*	1,016	1,551	29,283	53,465	17,280	148,794	17,665	54,044	-	50,571	3,524	2,578	24,052	1,266	18,923	13,697	437,710
42	2010 production from plantations	*d.*	*kton/yr*	1,870	71	705	138,194	65,406	21,754	73	954	-	1,582	213	645	1,012	490	2,148	5,190	240,306
43	2010 production from other wooded lands (no rubber, coconut, palm oil)	*d.*	*kton/yr*	203	206	783	15,591	2,002	4,035	4,788	-	-	11,686	390	640	-	57	-	6,790	47,170

Note: only direct, natural sources are considered here. Wood used for construction and furniture may end up as fuelwood, but no estimates could be made because a lot may be exported or disposed of in other ways.

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
Wood from agricultural lands																				
44	1984 agr. area	*FAOSTAT*	*1000 ha*	9,732	394	2,691	461,746	181,080	37,052	1,610	5,565	4	10,422	4,289	25,330	10,060	2,311	20,051	6,910	779,247
45	1994 agr. area	*FAOSTAT*	*1000 ha*	9,300	413	5,338	495,782	181,000	41,971	1,700	7,885	4	10,421	4,500	26,510	10,650	2,323	21,245	7,086	826,128
46	Av. an. increase 1984-1994	*d.*	*1000 ha*	(43)	2	265	3,404	(8)	492	9	232	-	(0)	21	118	59	1	119	18	4,688
47	Av. an. growth rate agr. area 1984-1994	*d.*	*percent*	(0.5)	0.5	7.1	0.7	(0.0)	1.3	0.5	3.5	-	(0.0)	0.5	0.5	0.6	0.1	0.6	0.3	0.6
48	1994 agr. area of cocoa, tea, coffee	*es.*	*1000 ha*	48	-	-	894	654	1,127	12	261	-	4	1	-	158	215	87	177	3,638
49	1994 other agr. areas	*es.*	*1000 ha*	9,252	413	5,338	494,888	180,346	40,844	1,688	7,624	4	10,417	4,499	26,510	10,492	2,108	21,159	6,909	822,490
50	2010 agr. area	*ex.*	*1000 ha*	9,300	443	9,573	550,240	181,000	49,841	1,844	11,597	4	10,421	4,838	28,398	11,594	2,342	23,155	7,368	901,958
51	2010 agr. area of cocoa, tea, coffee	*es.*	*1000 ha*	53	-	-	604	729	1,734	27	459	-	6	1	-	157	161	145	481	4,555
52	Other agr. areas	*es.*	*1000 ha*	9,248	443	9,573	549,636	180,271	48,107	1,818	11,138	4	10,416	4,837	28,398	11,437	2,181	23,011	6,887	897,404

Agriculture area available from FAO Data Base. Area of coffee, tea and cocoa estimated from production and productivity. Agriculture area in 2010 projected based on the assumption that area will remain constant in case of decrease over 1984-1994 (e.g. Bangladesh, India) or increase with the same average constant annual increase as during 1984-1994.

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
53	1994 wood productivity from other agr. land	*as.*	*m3/ha/y*	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
54	availability for fuel	*as.*	*percent*	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
55	1994 woodfuel production from agr. areas	*es.*	*kton/yr*	5,363	239	3,094	286,892	104,548	23,678	979	4,420	2	6,039	2,608	15,368	6,082	1,222	12,266	4,005	476,806
56	1994 wood production from rubber, palm oil, coconut, cocoa, tea, coffee	*es.*	*kton/y*	229	-	299	1,809	20,774	44,066	-	13,389	32	845	-	2	24,737	4,051	10,977	3,391	124,601
57	2010 woodfuel production from agr. areas	*es.*	*kton/yr*	5,361	257	5,550	318,630	104,505	27,888	1,054	6,457	2	6,038	2,804	16,463	6,630	1,264	13,340	3,992	520,234
58	2010 wood production from rubber, palm oil, coconut, cocoa, tea, coffee	*es.*	*kton/y*	275	-	506	3,442	33,627	56,924	-	15,953	39	1,246	-	2	32,547	4,750	17,762	4,780	171,854

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
Land Use																				
59	Total land area	*FAOSTAT*	*1000 ha*	13,017	4,700	17,652	932,641	297,319	181,157	23,080	32,855	30	65,755	14,300	77,088	29,817	6,463	51,089	32,549	1,779,512
60	Total considered area	*d.*	*1000 ha*	10,763	3,523	16,722	656,941	263,416	181,196	22,394	27,936	4	58,247	9,994	29,363	23,022	6,232	34,579	29,920	1,374,252
61	Percentage considered of total area	*d.*	*percent*	83%	75%	95%	70%	89%	100%	97%	85%	13%	89%	70%	38%	77%	96%	68%	92%	77%

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
	Fuelwood Production in 1994																			
62	from natural forests (sust)		*kton/y*	737	3,797	13,869	119,329	35,800	161,711	18,446	31,321	-	44,957	3,990	1,364	12,195	1,438	10,840	10,814	470,608
63	from natural forests (wood waste)		*kton/y*	1,426	1,678	63,311	58,347	18,999	181,526	21,767	87,754	-	65,341	4,258	4,598	45,486	1,529	31,046	18,498	605,565
64	from plantations (sust)		*kton/y*	1,028	25	160	116,212	49,895	21,394	26	416	-	970	199	596	767	485	1,902	5,128	199,204
65	from other wooded lands (sust)		*kton/y*	215	206	831	15,957	5,150	6,673	4,788	-	-	11,782	390	640	-	239	-	7,124	53,994
66	from agricultural areas (sustainable)		*kton/y*	5,593	239	3,394	288,700	125,323	67,744	979	17,809	34	6,884	2,608	15,371	30,819	5,273	23,243	7,396	601,407
67	**total 1994 fuelwood production**		*kton/y*	**8,999**	**5,946**	**81,565**	**598,546**	**235,167**	**439,049**	**46,006**	**137,301**	**34**	**129,935**	**11,444**	**22,569**	**89,267**	**8,963**	**67,030**	**48,960**	**1,930,778**
68	from natural forests (sust)		*PJ/y*	11	57	208	1,790	537	2,426	277	470	-	674	60	20	183	22	163	162	7,059
69	from natural forests (wood waste)		*PJ/y*	21	25	950	875	285	2,723	327	1,316	-	980	64	69	682	23	466	277	9,083
70	from plantations (sust)		*PJ/y*	15	0	2	1,743	748	321	0	6	-	15	3	9	12	7	29	77	2,988
71	from other wooded lands (sust)		*PJ/y*	3	3	12	239	77	100	72	-	-	177	6	10	-	4	-	107	810
72	from agricultural areas (sustainable)		*PJ/y*	84	4	51	4,331	1,880	1,016	15	267	1	103	39	231	462	79	349	111	9,021
73	**total 1994 fuelwood production**		*PJ/y*	**135**	**89**	**1,223**	**8,978**	**3,528**	**6,586**	**690**	**2,060**	**1**	**1,949**	**172**	**339**	**1,339**	**134**	**1,005**	**734**	**28,962**
	Fuelwood Requirements in 1994																			
74	**total 1994 requirements**	*RWEDP/EDP*	*PJ/y*	**141**	**12**	**81**	**3,287**	**2,601**	**817**	**35**	**93**	**1**	**346**	**192**	**520**	**346**	**85**	**691**	**441**	**9,688**
75	from forest	*es.*	*PJ/y*	18	2	26	1,052	780	261	11	30	0	111	127	140	52	21	346	110	3,088
76	from agr. land+other sources	*es.*	*PJ/y*	123	10	55	2,235	1,821	556	24	63	1	235	65	380	294	64	346	330	6,601
77	total 1994 requirements	*RWEDP/EDP*	*1000 m3/y*	14,455	1,260	8,269	337,110	266,788	83,806	3,583	9,519	123	35,474	19,673	53,364	35,463	8,740	70,875	45,182	993,684
78	**total 1994 requirements**	*d.*	*kton/y*	**9,396**	**819**	**5,375**	**219,122**	**173,412**	**54,474**	**2,329**	**6,187**	**80**	**23,058**	**12,787**	**34,687**	**23,051**	**5,681**	**46,069**	**29,368**	**645,895**
79	from forest	*as.*	*percent*	13%	17%	32%	32%	30%	32%	32%	32%	32%	32%	66%	27%	15%	25%	50%	25%	32%
80	from forest	*es.*	*kton/y*	1,221	139	1,720	70,119	52,024	17,432	745	1,980	26	7,379	8,440	9,365	3,458	1,420	23,034	7,342	205,844
81	from agr. land+other sources	*es.*	*kton/y*	8,174	680	3,655	149,003	121,389	37,042	1,584	4,207	54	15,680	4,348	25,321	19,593	4,261	23,034	22,026	440,051

				BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
	Fuelwood Production in 2010																			
82	from natural forests (sust)		*kton/y*	546	3,539	7,000	110,412	32,908	135,528	15,323	20,370	-	35,806	3,373	816	6,929	1,216	6,985	8,282	389,032
83	from natural forests (wood waste)		*kton/y*	1,016	1,551	29,283	53,465	17,280	148,794	17,665	54,044	-	50,571	3,524	2,578	24,052	1,266	18,923	13,697	437,710
84	from plantations (sust)		*kton/y*	1,870	71	705	138,194	65,406	21,754	73	954	-	1,582	213	645	1,012	490	2,148	5,190	240,306
85	from other wooded lands (sust)		*kton/y*	203	206	783	15,591	2,002	4,035	4,788	-	-	11,686	390	640	-	57	-	6,790	47,170
86	from agricultural areas (sustainable)		*kton/y*	5,636	257	6,056	322,072	138,132	84,813	1,054	22,409	41	7,284	2,804	16,465	39,177	6,015	31,101	8,772	692,088
87	**total 2010 fuelwood production**		*kton/y*	**9,271**	**5,624**	**43,827**	**639,733**	**255,729**	**394,923**	**38,902**	**97,777**	**41**	**106,930**	**10,304**	**21,144**	**71,171**	**9,044**	**59,157**	**42,730**	**1,806,307**
88	from natural forests (sust)		*PJ/y*	8	53	105	1,656	494	2,033	230	306	-	537	51	12	104	18	105	124	5,835
89	from natural forests (wood waste)		*PJ/y*	15	23	439	802	259	2,232	265	811	-	759	53	39	361	19	284	205	6,566
90	from plantations (sust)		*PJ/y*	28	1	11	2,073	981	326	1	14	-	24	3	10	15	7	32	78	3,605
91	from other wooded lands (sust)		*PJ/y*	3	3	12	234	30	61	72	-	-	175	6	10	-	1	-	102	708
92	from agricultural areas (sustainable)		*PJ/y*	85	4	91	4,831	2,072	1,272	16	336	1	109	42	247	588	90	467	132	10,381
93	**total 2010 fuelwood production**		*PJ/y*	**139**	**84**	**657**	**9,596**	**3,836**	**5,924**	**584**	**1,467**	**1**	**1,604**	**155**	**317**	**1,068**	**136**	**887**	**641**	**27,095**
	Fuelwood Requirements in 2010																			
94	**total 2010 fuelwood requirements:**	*ex.*	*PJ/y*	**200**	**18**	**113**	**3,792**	**3,386**	**1,012**	**52**	**123**	**2**	**468**	**276**	**783**	**455**	**102**	**801**	**591**	**12,173**
95	from forest	*es.*	*PJ/y*	26	3	36	1,214	1,016	324	17	39	1	150	182	211	68	25	400	148	3,860
96	from agr. land+other sources	*es.*	*PJ/y*	174	15	77	2,579	2,370	688	36	84	1	318	94	571	387	76	400	443	8,313
97	growth rates in WE consumption	*as.*	*percent*	2.21%	2.39%	2.15%	0.90%	1.66%	1.35%	2.57%	1.79%	2.75%	1.90%	2.29%	2.58%	1.73%	1.10%	0.93%	1.86%	1.44%
98	**estimated 2010 requirements:**	*ex.*	*kton/y*	**13,320**	**1,195**	**7,553**	**252,819**	**225,725**	**67,465**	**3,496**	**8,216**	**123**	**31,183**	**18,378**	**52,167**	**30,329**	**6,769**	**53,390**	**39,418**	**811,548**
99	from forest	*as.*	*percent*	13%	17%	32%	32%	30%	32%	32%	32%	32%	32%	66%	27%	15%	25%	50%	25%	32%
100	from forest	*es.*	*kton/y*	1,732	203	2,417	80,902	67,718	21,589	1,119	2,629	39	9,978	12,130	14,085	4,549	1,692	26,695	9,854	257,332
101	from agr. land+other sources	*es.*	*kton/y*	11,588	992	5,136	171,917	158,008	45,876	2,377	5,587	84	21,204	6,249	38,082	25,780	5,077	26,695	29,563	554,216

Projection of fuelwood consumption based on population growth estimates available from World Resources 94-95 (WRI, 1995), with correlation coefficient 1.

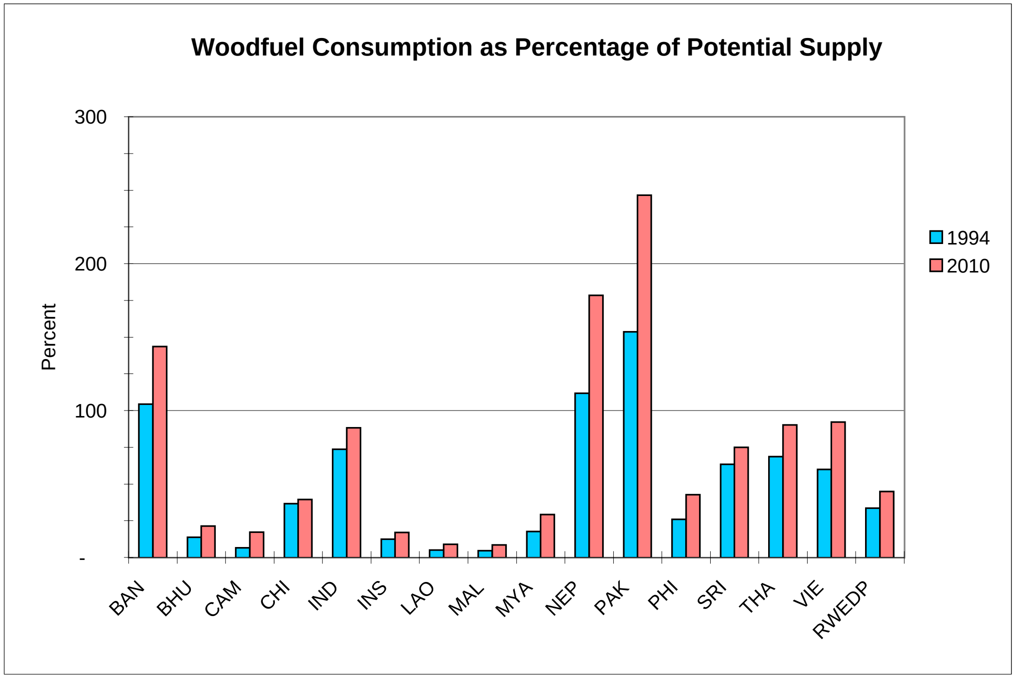
FAO 90: FAO Forest Resources Assessment 1990 (FAO, 1993) *a: assumed* *ex: extrapolated*
FAO 97: FAO State of the World's Forest 1997 (FAO, 1997a) *d: derived* *es: estimated*
FAOSTAT: FAOSTAT Data Base *in: interpolated*

Overview of Woodfuel Consumption and Production

Unit: PJ

		BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
Potential Woodfuel Supply	1994	135	89	1,223	8,978	3,528	6,586	690	2,060	0.5	1,949	172	339	1,339	134	1,005	734	28,962
Woodfuel Consumption	1994	141	12	81	3,287	2,601	817	35	93	1.2	346	192	520	346	85	691	441	9,688
Consumption as % of Pot. Supply	1994	104	14	7	37	74	12	5	5	235	18	112	154	26	63	69	60	33
Potential Woodfuel Supply	2010	139	84	657	9,596	3,836	5,924	584	1,467	1	1,604	155	317	1,068	136	887	641	27,095
Woodfuel Consumption	2010	200	18	113	3,792	3,386	1,012	52	123	2	468	276	783	455	102	801	591	12,173
Consumption as % of Pot. Supply	2010	144	21	17	40	88	17	9	8	299	29	178	247	43	75	90	92	45

Note: a percentage of more than 100% means a gap between supply and demand of woodfuels



Box 4

R&D For Residue Combustion

Diverse residues from biomass, including crop residues, are widely used as an affordable substitute for the more preferred fuels like wood. The present users include poor households and many traditional industries. Future use may increase under conditions of increasing pressure on local fuelwood resources, and/or further marginalization of certain population groups.

Crop residues like rice husks and straw, coconut husks and shells, palm oil kernels, shells and fibre, as well as saw dust and other loose biomass provide a vast potential for fuel use. This holds true even under the conservative assumption that only half of the processing residues would be used as a fuel.

As yet, most residue fuels are bulky to transport, difficult to handle, and inconvenient and unhealthy to combust. More R&D should be and can be done to upgrade future fuels from crop residues and improve their combustion characteristics by cost-effective technologies.

Reference is made to the following RWEDP publications

- Biomass Briquetting: Technology and Practices,(Grover, P.D. and Mishra, S.K., 1996)
- Proceedings of the International Workshop on Biomass Briquetting, (Grover P.D and Mishra, S.K. (ed), 1996)
- Proceedings of the Workshop on Stoves for Use with Loose Residues (RWEDP, 1997a)
- Proceedings of the Regional Expert Consultation on Selection Criteria and Priority Rating for Assistance to Traditional Biomass Energy Using Industries (RWEDP, 1997b)
- Proceedings of the Regional Consultation on Introducing Modern Technologies and Systems for Efficient Use of Wood and Biomass for Major Types of Industries or Ecological/Economic Situations (RWEDP, 1997c)

Potential Production of Crop Residue Fuel in 1994

PRODUCTION OF CROPS IN KILOTON, 1994

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Rice	Straw	1.757	25,248	43	2,223	178,031	121,997	46,641	1,653	2,156	0	18,195	2,928	5,170	10,538	2,684	21,111	23,528	462,146
Wheat	Straw	1.750	1,131	5	0	99,303	59,131	0	0	0	0	109	873	15,213	0	0	1	0	175,766
Millet	Stalks	1.750	63	7	0	3,697	11,098	0	0	0	0	123	268	228	0	7	0	0	15,491
Maize	Stalks	2.000	3	40	65	99,622	9,490	6,869	77	40	0	284	1,273	1,318	4,519	32	3,965	1,001	128,598
Cassave	Stalks	0.062	0	0	36	3,501	5,784	15,729	68	440	0	66	0	0	1,850	298	19,091	2,430	49,293
Cotton	Stalks	2.755	51	0	0	13,023	7,039	24	23	0	0	68	0	4,438	8	0	78	18	24,770
Soyabeans	Straw+pods	3.500	0	1	23	16,011	3,676	1,565	5	0	0	34	11	3	4	1	528	125	21,987
Jute	Stalk	2.000	797	0	2	380	1,527	19	0	0	0	27	11	0	0	0	133	28	2,924
Tobacco	Stalks																		0
Sugar cane	Tops	0.300	7,601	13	219	66,430	227,060	30,272	141	1,541	0	2,849	1,431	44,427	28,100	1,529	37,823	7,550	456,986
Cocoa	Pods	1.000	0	0	0	0	7	271	0	177	0	0	0	0	8	4	0	0	467

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Rice	Husk	0.267	25,248	43	2,223	178,031	121,997	46,641	1,653	2,156	0	18,195	2,928	5,170	10,538	2,684	21,111	23,528	462,146
Rice	Bran	0.083	25,248	43	2,223	178,031	121,997	46,641	1,653	2,156	0	18,195	2,928	5,170	10,538	2,684	21,111	23,528	462,146
Maize	Cob	0.273	3	40	65	99,622	9,490	6,869	77	40	0	284	1,273	1,318	4,519	32	3,965	1,001	128,598
Maize	Husks	0.200	3	40	65	99,622	9,490	6,869	77	40	0	284	1,273	1,318	4,519	32	3,965	1,001	128,598
Coconut	Shells	0.120	94		53	75	7,800	13,868		1,005	13	320		1	9,800	1,476	1,476	1,190	37,171
Coconut	Husks	0.419	94		53	75	7,800	13,868		1,005	13	320		1	9,800	1,476	1,476	1,190	37,171
Groundnut	Shells	0.477	41	0	5	9,763	8,260	903	6	5	0	431	0	106	37	4	150	294	20,005
Groundnut	Straw	2.300	41	0	5	9,763	8,260	903	6	5	0	431	0	106	37	4	150	294	20,005
Oil Palm ???	Fibre	0.140				150		4,095		7,221					59		300		11,825
Oil Palm ???	Shell	0.065				150		4,095		7,221					59		300		11,825
Oil Palm ???	Bunches	0.230				150		4,095		7,221					59		300		11,825
Sugar cane	Bagasse	0.290	7,601	13	219	66,430	227,060	30,272	141	1,541	0	2,849	1,431	44,427	28,100	1,529	37,823	7,550	456,986
Coffee	Husk	2.100	0	0	0	44	170	346	6	11	0	1	0	0	122	11	72	166	949

Sources:
Crop production data: Selected Indicators of Food and Agriculture Development in Asia-Pacific Region 1985-1995. FAO-RAP Publication 1996/32 (FAO, 1996b)
Residue to product ratio (RPR): Traditional Energy Use and Availability of Agricultural and Forest Residues, (Koopmans A., 1995)

ESTIMATED AMOUNT OF RESIDUES PRODUCED IN THE 16 RWEDP MEMBER COUNTRIES IN 1994 BASED ON RESIDUE TO PRODUCT RATIO DATA (* 1,000 Tons)

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
FIELD BASED RESIDUES																			
Rice	Straw	1.757	44,361	76	3,906	312,800	214,349	81,948	2,904	3,788	0	31,969	5,144	9,084	18,515	4,716	37,092	41,339	811,991
Wheat	Straw	1.750	1,979	9	0	173,780	103,479	0	0	0	0	191	1,528	26,623	0	0	2	0	307,591
Millet	Stalks	1.750	110	12	0	6,470	19,422	0	0	0	0	215	469	399	0	12	0	0	27,109
Maize	Stalks	2.000	6	80	130	199,244	18,980	13,738	154	80	0	568	2,546	2,636	9,038	64	7,930	2,002	257,196
Cassave	Stalks	0.062	0	0	2	217	359	975	4	27	0	4	0	0	115	18	1,184	151	3,056
Cotton	Stalks	2.755	141	0	0	35,878	19,392	66	63	0	0	187	0	12,227	22	0	215	50	68,241
Soyabeans	Straw+pods	3.500	0	5	81	56,039	12,866	5,478	18	0	0	119	39	11	14	4	1,848	438	76,956
Jute	Stalks	3.000	2,391	0	6	1,140	4,581	57	0	0	0	81	33	0	0	0	399	84	8,772
Tobacco	Stalks, etc.	2.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar cane	Tops	0.300	2,280	4	66	19,929	68,118	9,082	42	462	0	855	429	13,328	8,430	459	11,347	2,265	137,096
Cocoa	Pods	1.000	0	0	0	0	7	271	0	177	0	0	0	0	8	4	0	0	467

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
PROCESSING BASED RESIDUES																			
Rice	Husk	0.267	6,741	11	594	47,534	32,573	12,453	441	576	0	4,858	782	1,380	2,814	717	5,637	6,282	123,393
Rice	Bran	0.083	2,096	4	185	14,777	10,126	3,871	137	179	0	1,510	243	429	875	223	1,752	1,953	38,358
Maize	Cob	0.273	1	11	18	27,197	2,591	1,875	21	11	0	78	348	360	1,234	9	1,082	273	35,107
Maize	Husks	0.200	1	8	13	19,924	1,898	1,374	15	8	0	57	255	264	904	6	793	200	25,720
Coconut	Shells	0.120	11	0	6	9	936	1,664	0	121	2	38	0	0	1,176	177	177	143	4,461
Coconut	Husks	0.419	39	0	22	31	3,268	5,811	0	421	5	134	0	0	4,106	618	618	499	15,575
Groundnut	Husks	0.477	20	0	2	4,657	3,940	431	3	2	0	206	0	51	18	2	72	140	9,542
Groundnut	Straw	2.300	94	0	12	22,455	18,998	2,077	14	12	0	991	0	244	85	9	345	676	46,012
Oil Palm	Fibre	0.140	0	0	0	21	0	573	0	1,011	0	0	0	0	8	0	42	0	1,656
Oil Palm	Shell	0.065	0	0	0	10	0	266	0	469	0	0	0	0	4	0	20	0	769
Oil Palm	Bunches	0.230	0	0	0	35	0	942	0	1,661	0	0	0	0	14	0	69	0	2,720
Sugar cane	Bagasse	0.290	2,204	4	64	19,265	65,847	8,779	41	447	0	826	415	12,884	8,149	443	10,969	2,190	132,526
Coffee	Husk	2.100	0	0	0	92	357	727	13	23	0	2	0	0	256	23	151	349	435,837

	Unit	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Total Biomass Residues (field based)	kton	51,268	185	4,190	805,497	461,553	111,615	3,186	4,535	-	34,189	10,188	64,307	36,142	5,277	60,016	46,327	1,698,474
Total Biomass Residues (process based)	kton	11,207	38	915	156,007	140,534	40,843	685	4,940	7	8,700	2,042	15,612	19,642	2,228	21,727	12,704	437,830
Availability of field residues for fuel		0%																
Availability of process residues for fuel		50%																
Biomass Residue Fuel (field based)	kton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biomass Residue Fuel (process based)	kton	5,604	19	457	78,003	70,267	20,421	343	2,470	4	4,350	1,021	7,806	9,821	1,114	10,863	6,352	218,915
Biomass Residue Fuel (field based)	PJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biomass Residue Fuel (process based)	PJ	88	0	7	1,169	1,143	327	5	32	0	66	16	137	169	19	181	99	3,458

Availability of field residues is assumed to be 0% because they are difficult to collect from the field and the are often used for fertilizing

Availability of process residues is constrained due to other end-uses such as isolation material, feed and fodder.

CROP PRODUCTION AND AMOUNT OF RESIDUES PRODUCED IN 1994 (* 1,000 Tons) AND OIL EQUIVALENT

Crop	Type	Residue	LHV(MJ/kg)	Crops (kton)	Residues (kton)	Oil equiv. (kton)	PJ
Field-based residues							
Rice	Straw	1.757	16.02	462,146	811,991	305,354	13,008
Wheat	Straw	1.750	12.38	175,766	307,591	89,389	3,808
Millet	Stalks	1.750	12.38	15,491	27,109	7,878	336
Maize	Stalks	2.000	16.80	128,598	257,196	101,429	4,321
Cassave	Stalks	0.062	17.50	49,293	3,056	1,255	53
Cotton	Stalks	2.755	12.38	24,770	68,241	19,832	845
Soyabeans	Straw+pods	3.500	12.38	21,987	76,956	22,364	953
Jute	Stalks	3.000	12.38	2,924	8,772	2,549	109
Tobacco	Stalks, etc.	2.000		0	0	0	0
Sugar cane	Tops	0.300	15.81	456,986	137,096	50,880	2,167
Cocoa	Pods	1.000	12.38	467	467	136	6
Processing-based residues							
Rice	Husk	0.267	15.58	462,146	123,393	45,128	1,922
Rice	Bran	0.083	13.97	462,146	38,358	12,579	536
Maize	Cob	0.273	16.28	128,598	35,107	13,417	572
Maize	Husks	0.200	12.38	128,598	25,720	7,474	318
Coconut	Shells	0.120	18.10	37,171	4,461	1,895	81
Coconut	Husks	0.419	18.62	37,171	15,575	6,808	290
Groundnut	Husks	0.477	15.66	20,005	9,542	3,508	149
Groundnut	Straw	2.300	12.38	20,005	46,012	13,371	570
Oil Palm	Fibre	0.140	11.34	11,825	1,656	441	19
Oil Palm	Shell	0.065	18.83	11,825	769	340	14
Oil Palm	Bunches	0.230	8.16	11,825	2,720	521	22
Sugar cane	Bagasse	0.290	18.10	456,986	132,526	56,308	2,399
Coffee	Husk	2.100	12.38	949	1,993	579	25
TOTAL AMOUNT OF FIELD BASED RESIDUES					1,698,474	601,067	25,605
TOTAL AMOUNT OF PROCESSING BASED RESIDUES					437,830	162,369	6,917
TOTAL AMOUNT OF AGRICULTURAL CROP RESIDUES					2,136,304	763,436	32,522

Lower Heating Values (LHV) for crop residues available from: Traditional Energy Use and Availability of Agricultural and Forest Residues (Koopmans, A., 1995)

Potential Production of Crop Residue Fuel in 2010

PRODUCTION OF CROPS IN KILOTON, 2010

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Rice	Straw	1.757	27,814	15	1,825	211,051	162,203	66,101	1,430	2,542		28,797	2,927	7,718	14,296	2,719	22,429	36,188	588,052
Wheat	Straw	1.750	804			126,817	91,414					59	1,418	24,951			1		245,463
Millet	Stalks	1.750	18	7		286	10,152					53	364	113		3			10,994
Maize	Stalks	2.000	3		50	184,750	14,534	14,063	151	72		232	1,697	1,674	4,520	35	2,512	2,120	226,409
Cassave	Stalks	0.062			5	3,266	6,507	17,819	68	524					2,145		16,516	1,833	48,680
Cotton	Stalks	2.755	128			17,099	11,176		34			26		8,285			35	39	36,820
Soyabeans	Straw+pods	3.500		0	81	18,027	9,964	2,918	5			91	25	5			857	219	32,189
Jute	Stalk	2.000			1		404	37				10							451
Tobacco	Stalks																		0
Sugar cane	Tops	0.300	8,686	16		89,244	393,247	41,749	207	2,383			3,035	69,710	29,600	2,692	88,910	12,160	741,636
Cocoa	Pods	1.000					9	557		179					11	6			761

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Rice	Husk	0.267	27,814	15	1,825	211,051	162,203	66,101	1,430	2,542		28,797	2,927	7,718	14,296	2,719	22,429	36,188	588,052
Rice	Bran	0.083	27,814	15	1,825	211,051	162,203	66,101	1,430	2,542		28,797	2,927	7,718	14,296	2,719	22,429	36,188	588,052
Maize	Cob	0.273	3		50	184,750	14,534	14,063	151	72		232	1,697	1,674	4,520	35	2,512	2,120	226,409
Maize	Husks	0.200	3		50	184,750	14,534	14,063	151	72		232	1,697	1,674	4,520	35	2,512	2,120	226,409
Coconut	Shells	0.120	113		76	88	12,455	15,965		796	16	439		3	12,850	1,849	1,824	1,582	48,053
Coconut	Husks	0.419	113		76	88	12,455	15,965		796	16	439		3	12,850	1,849	1,824	1,582	48,053
Groundnut	Shells	0.477	55		5	15,661	10,069	963		2		252		171	31	1	119	460	27,786
Groundnut	Straw	2.300	55		5	15,661	10,069	963		2		252		171	31	1	119	460	27,786
Oil Palm ???	Fibre	0.140				105		8,886		13,327					111		792		23,219
Oil Palm ???	Shell	0.065				105		8,886		13,327					111		792		23,219
Oil Palm ???	Bunches	0.230				105		8,886		13,327					111		792		23,219
Sugar cane	Bagasse	0.290	8,686	16		89,244	393,247	41,749	207	2,383			3,035	69,710	29,600	2,692	88,910	12,160	741,636
Coffee	Husk	2.100				83	133	399	16	11		1			135	14	147	445	1,382

Production assumed to increase with the same average annual increase as during 1985-1995. In case of a decrease, production was assumed to be as in 1995

ESTIMATED AMOUNT OF RESIDUES PRODUCED IN THE 16 RWEDP MEMBER COUNTRIES IN 2010 BASED ON RESIDUE TO PRODUCT RATIO DATA (* 1,000 Tons)

Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
FIELD BASED RESIDUES																			
Rice	Straw	1.757	48,868	25	3,206	370,817	284,991	116,139	2,513	4,465	0	50,596	5,143	13,561	25,118	4,776	39,408	63,581	1,033,206
Wheat	Straw	1.750	1,407	0	0	221,930	159,975	0	0	0	0	102	2,481	43,663	0	0	2	0	429,559
Millet	Stalks	1.750	31	12	0	500	17,765	0	0	0	0	92	637	198	0	4	0	0	19,239
Maize	Stalks	2.000	6	0	100	369,499	29,068	28,125	302	143	0	463	3,393	3,348	9,039	70	5,023	4,239	452,818
Cassave	Stalks	0.062	0	0	0	202	403	1,105	4	32	0	0	0	0	133	0	1,024	114	3,018
Cotton	Stalks	2.755	351	0	0	47,106	30,790	0	92	0	0	72	0	22,825	0	0	95	107	101,439
Soyabeans	Straw+pods	3.500	0	1	282	63,095	34,874	10,211	18	0	0	317	86	16	0	0	2,998	767	112,662
Jute	Stalks	3.000	0	0	2	0	1,211	111	0	0	0	29	0	0	0	0	0	0	1,352
Tobacco	Stalks, etc.	2.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar cane	Tops	0.300	2,606	5	0	26,773	117,974	12,525	62	715	0	0	911	20,913	8,880	807	26,673	3,648	222,491
Cocoa	Pods	1.000	0	0	0	0	9	557	0	179	0	0	0	0	11	6	0	0	761
Crop	Residue type	RPR	BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
PROCESSING BASED RESIDUES																			
Rice	Husk	0.267	7,426	4	487	56,351	43,308	17,649	382	679	0	7,689	782	2,061	3,817	726	5,989	9,662	157,010
Rice	Bran	0.083	2,309	1	151	17,517	13,463	5,486	119	211	0	2,390	243	641	1,187	226	1,862	3,004	48,808
Maize	Cob	0.273	1	0	14	50,437	3,968	3,839	41	20	0	63	463	457	1,234	10	686	579	61,810
Maize	Husks	0.200	1	0	10	36,950	2,907	2,813	30	14	0	46	339	335	904	7	502	424	45,282
Coconut	Shells	0.120	14	0	9	11	1,495	1,916	0	95	2	53	0	0	1,542	222	219	190	5,766
Coconut	Husks	0.419	47	0	32	37	5,219	6,689	0	333	7	184	0	1	5,384	775	764	663	20,134
Groundnut	Husks	0.477	26	0	2	7,470	4,803	459	0	1	0	120	0	81	15	0	57	219	13,254
Groundnut	Straw	2.300	125	0	12	36,019	23,158	2,215	0	5	0	580	0	392	71	2	273	1,057	63,908
Oil Palm	Fibre	0.140	0	0	0	15	0	1,244	0	1,866	0	0	0	0	16	0	111	0	3,251
Oil Palm	Shell	0.065	0	0	0	7	0	578	0	866	0	0	0	0	7	0	51	0	1,509
Oil Palm	Bunches	0.230	0	0	0	24	0	2,044	0	3,065	0	0	0	0	25	0	182	0	5,340
Sugar cane	Bagasse	0.290	2,519	5	0	25,881	114,041	12,107	60	691	0	0	880	20,216	8,584	781	25,784	3,526	215,074
Coffee	Husk	2.100	0	0	0	173	278	837	34	23	0	2	0	0	284	29	309	933	2,902

Source: Production data - Selected Indicators of Food and Agriculture Development in Asia-Pacific Region 1985-1995. FAO-RAP Publication 1996/32 (FAO, 1996a)

			BGD	BHU	CMB	CPR	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRL	THA	VIE	RWEDP
Total Biomass Residues (field bas		kton	53,269	43	3,589	1,099,921	677,059	168,772	2,991	5,535	-	51,670	12,650	104,524	43,181	5,664	75,222	72,456	2,376,545
Total Biomass Residues (process		kton	12,467	10	717	230,890	212,639	57,875	666	7,869	9	11,127	2,707	24,184	23,069	2,777	36,787	20,257	644,049
Availability of field residues for fuel			0%																
Availability of process residues for fuel			50%																
Biomass Residue Fuel (field base		kton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biomass Residue Fuel (process b		kton	6,234	5	358	115,445	106,319	28,938	333	3,934	4	5,563	1,354	12,092	11,535	1,389	18,393	10,128	322,024
Biomass Residue Fuel (field base		PJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biomass Residue Fuel (process b		PJ	98	0	5	1,718	1,759	457	5	49	0	84	22	212	198	24	317	157	5,105

CROP PRODUCTION AND AMOUNT OF RESIDUES PRODUCED IN 2010 (* 1,000 Tons) AND OIL EQUIVALENT

Crop	Type	Residue	LHV	Crops (kton)	Residues (kton)	Oil equiv. (kton)	PJ
Field-based residues							
Rice	Straw	1.757	16.02	588,052	1,033,206	388,544	16,552
Wheat	Straw	1.750	12.38	245,463	429,559	124,834	5,318
Millet	Stalks	1.750	12.38	10,994	19,239	5,591	238
Maize	Stalks	2.000	16.80	226,409	452,818	178,576	7,607
Cassave	Stalks	0.062	17.50	48,680	3,018	1,240	53
Cotton	Stalks	2.755	12.38	36,820	101,439	29,479	1,256
Soyabeans	Straw+pods	3.500	12.38	32,189	112,662	32,741	1,395
Jute	Stalks	3.000	12.38	451	1,352	393	17
Tobacco	Stalks, etc.	2.000		0	0	0	0
Sugar cane	Tops	0.300	15.81	741,636	222,491	82,572	3,518
Cocoa	Pods	1.000	12.38	761	761	221	9
Processing-based residues							
Rice	Husk	0.267	15.58	588,052	157,010	57,423	2,446
Rice	Bran	0.083	13.97	588,052	48,808	16,006	682
Maize	Cob	0.273	16.28	226,409	61,810	23,621	1,006
Maize	Husks	0.200	12.38	226,409	45,282	13,159	561
Coconut	Shells	0.120	18.10	48,053	5,766	2,450	104
Coconut	Husks	0.419	18.62	48,053	20,134	8,800	375
Groundnut	Husks	0.477	15.66	27,786	13,254	4,872	208
Groundnut	Straw	2.300	12.38	27,786	63,908	18,572	791
Oil Palm	Fibre	0.140	11.34	23,219	3,251	865	37
Oil Palm	Shell	0.065	18.83	23,219	1,509	667	28
Oil Palm	Bunches	0.230	8.16	23,219	5,340	1,023	44
Sugar cane	Bagasse	0.290	18.10	741,636	215,074	91,381	3,893
Coffee	Husk	2.100	12.38	1,382	2,902	843	36
TOTAL AMOUNT OF FIELD BASED RESIDUES					2,376,545	844,191	35,963
TOTAL AMOUNT OF PROCESSING BASED RESIDUES					644,049	239,684	10,211
TOTAL AMOUNT OF AGRICULTURAL CROP RESIDUES					3,020,594	1,083,876	46,173

9. IMPLICATIONS OF WOODFUEL USE FOR GREENHOUSE GAS EMISSIONS

Valuable Waste!!

9.1 CO_2 Emissions

The implications of woodfuel use for the global environment can be evaluated by estimating the associated greenhouse gas emissions. As CO_2 is the main greenhouse gas, it only (carbon-dioxide) will be considered here, leaving aside gases like methane and other carbon-hydrogens. Any emissions caused by woodfuels can be compared with emissions from alternative fuels.

Though combusting wood emits CO_2 into the atmosphere, regrowth of wood captures CO_2 from the atmosphere. As a first approximation it can be stated that woodfuel use is carbon neutral, i.e. there is no net emission of carbon into the environment. The approximation is supported by the evidence of two dominant mechanisms. First, most woodfuel use takes place on a sustainable basis. This applies to the use of virtually all woodfuels originating from non-forest land (e.g. agriculture land, plantations and homegardens), and to the use of most of the woodfuels from forest land. Sustainability implies carbon neutrality, because the same amount of CO_2 emitted by wood combustion, is recaptured from the atmosphere by regrowth of wood. Second, leftovers from non-sustainable logging and land conversion, if not used as fuel (or for other purposes) would simply decompose by natural processes, and lead to the same amount of carbon emitted in the atmosphere if the woody material were to be combusted (though not necessarily distributed amongst CO_2, methane and other greenhouse gases in the same way).

Obviously, if woodfuels were not utilised, some alternative energy source would be required and used. For most applications and in most countries, the hypothetical alternative would be a fossil fuel, i.e. coal, gas, or oil products. For few applications and in few countries, hydro and wind power could be the hypothetical alternative, whereas within the next 15 years or so the option of other renewables like solar photo-voltaics is likely to be negligible in terms of energy quantity. The effects of fossil fuel use on the global atmosphere have been well documented. Typical data for the emission of CO_2 per fuel and per unit of energy are available from the LEAP Environmental Database (SEI, 1995). Furthermore, the other renewable energy sources are considered to be carbon neutral, like wood.

The implications of woodfuel use in Asia for the global environment can then be evaluated by estimating how much CO_2 emission from hypothetical alternatives is avoided by woodfuel use. The most likely (or least unlikely) mix of alternative energy sources varies per country. For the purpose of the present study, LPG can be considered the alternative. This leads to a simplistic though conservative estimate, because per unit of energy coal emits about 33% more and kerosene 7% more CO_2 than LPG[1]. The results are summarised in Table 9.1 and presented fully in Table 9.2. Switching between wood and other biomass fuels like agroresidues is ignored, because carbon neutrality applies to the other biomass fuels for the same reasons as for wood.

From Table 9.2 it is seen that in 1994 woodfuel use aggregated for the RWEDP member-countries results in avoided emission of about 277,683 kton CO_2 per annum as compared to hypothetical LPG use. This equals an average of 6 percent of the current CO_2 emission due to total fuel use in the same countries. By the year 2010 the figures would be 349,615 kton and 3% on average, respectively.

The economic benefit of current woodfuel use in Asia for the global environment can be appreciated by estimating the cost which would otherwise be required for avoiding or recapturing the emitted CO_2 from the atmosphere. Cost estimates for the latter vary a lot, depending on conditions and technological options (like removal, storage, recapturing, avoiding, etc., of the CO_2). Based on IPCC estimates (IPCC, 1997) 50 US$ per ton avoided/recaptured CO_2 is a typical figure within the present range of options. Hence, it can be estimated that in 1994 about 14 billion US$ and in 2010 about 17 billion US$, for CO_2-related costs are avoided by woodfuel use in RWEDP member-countries.

9.2 Example: Benefits of Wood Energy Development

The above estimates allow us to evaluate the benefits of a wood energy development programme like RWEDP for the global environment. RWEDP incorporates, amongst others, various activities in wood energy conservation, e.g. the promotion of improved stoves. This is being achieved in co-operation with government institutions, NGO's and donor agencies. When conservation is achieved, the ever increasing energy demand in the region can partly be met by available woodfuels, rather than fully resorting to additional fossil fuel with their associated CO_2 emissions. However, as firm data on achievements in wood energy conservation are not (yet) available, some assumptions have to be made[2].

The break-even point of a programme like RWEDP in terms of costs versus benefits for the global environment can be estimated as follows. On the cost side, the Dutch Government through FAO has allocated to RWEDP a total of 15.2 million US$ over the period 1984-1999.

On the benefit side, the same figure as above (50 US$/ton) for recapturing/avoiding CO_2 from the atmosphere can be applied. 'Environmental break-even' can thus be calculated for RWEDP in terms of avoided CO_2. This leads to the following results:

- If break-even is to be reached within, say, 10 years, a modest annual contribution from RWEDP of only 0.01% to wood energy conservation in the region would suffice. In fact, claiming such a limited impact seems to be very modest, perhaps even unrealistically small.

- If alternatively, the contribution of RWEDP to wood energy conservation in the region is assumed to be, say, 0.1% (which still seems to be modest[3]), the pay-back period of RWEDP would be only 11 months.

It should be noted that RWEDP has several objectives other than contributing to reducing greenhouse gas emissions. In fact, RWEDP's activities aim to support 6 sectoral priorities, of which only one is the environment, both locally and globally.

For comparison it is noted that the Government of The Netherlands has allocated the equivalent of 375 million US$ in its national budget for 1997 in order to achieve reduction of 15,290 kton CO_2 emissions into the global atmosphere in 5 years time, i.e. 3,058 kton per annum (Ministry of Agriculture, Nature Protection and Fisheries, 1997). This implies that the budget allows for a cost of 123 US$/ton CO_2. The programme will be implemented jointly by three Ministries (Economic Affairs, Environment, and Agriculture). It is quite likely that the same effect in terms of avoiding global CO_2 emission can be achieved by the Ministry for Development Cooperation and FAO via a dedicated wood energy conservation programme in Asia with a limited budget.

9.3 Global Environmental Policy

Many general policies regarding wood energy and environment are still based on the exceptional cases, i.e. the relatively few areas where woodfuel use is not sustainable. This even leads to donor policies for promotion of fuel transition, i.e. away from woodfuel towards fossil fuels or towards expensive forms of renewable energy. However, from available evidence it must be concluded that most woodfuel use takes place on a sustainable basis. Therefore it is more beneficial if people stick to the practice of woodfuel use for their daily needs. In terms of quantity of avoided CO_2 emission, the very fact of using wood energy by the majority of people is even more important than adoption of efficient wood stoves by a limited number of users. This observation may redirect priorities within wood energy conservation programmes. Rather than targeting at maximum efficiency of stoves with associated price increase of appliances, priorities should be for convenience, health and overall attractivity at affordable prices, so as to reach the maximum number of wood energy users. For areas where, indeed, woodfuel practices are not sustainable, tailor-made programmes should be designed.

As far as carbon sequestration through reforestation, afforestation and/or forest rehabilitation is an objective of present global environmental policies, it is obvious that such forest-related activities will be economically more feasible when the new or upgraded forest resource base will be available for sustainable use of wood and non-wood products. Sustainable woodfuel use qualifies as one of the prime applications in this context.

The above policy considerations are not only relevant for international agencies, but also for forest policy makers in Asia and the Pacific for an outlook to the year 2010. Further programmes and projects targeting wood energy development could be prepared and justified with a view to substantial global environmental benefits, not only for present RWEDP member-countries, but also for other countries in the Asia-Pacific region.

Table 9.1: **Summary for 16 RWEDP countries**

Environmental effects (kton)		**1994**	**2010**
CO_2 emission from fossil fuels*		4,317,000	10,602,000
avoided CO_2 emission by woodfuel use, as compared to **LPG**		278,000	349,000
ditto	as compared to **kerosene**	334,000	420,000
ditto	as compared to **coal**	560,000	703,000
avoided CO_2 costs, as compared to LPG (million US$)		14,000	17,500
Environmental break-even of woodfuels as compared to LPG			
If in 10 years, RWEDP should result in:	0.01% per annum w.e. conservation		
or if 0.1% p.a. wood energy is conserved via RWEDP:	pay-back in 11 months		

**1994 data from ORNL, 1997. 2010 projections made using projected growth rates from ESCAP 1997b.*

Notes:

[1] Based on the equivalence values of the fuels. If stove efficiencies would be taken into account, the respective values would be about 122% and 24% higher if coal and kerosene would be the alternatives.
[2] It is not easy to quantify the overall impact of a programme like RWEDP in terms of wood energy saving. How many improved household stoves are being adopted? Which part of that, if any, could be credited to RWEDP? How much woodfuel is saved by each improved stove? (China claims to have introduced 150 million improved stoves, and India some 25 million). And what about the many industrial and commercial users? Equally difficult is to quantify the impact of improved wood energy in terms of avoiding fossil fuel use. How many people decide to skip the option of a kerosene, coal or LPG stove, partly because their traditional wood stove has become more convenient, more efficient and less smoky? Or, partly because woodfuel supply (still) happens to be available? Again, which part of that could be credited to RWEDP? Even more difficult, or impossible, would be to try and estimate RWEDP's impact on the fuelwood resource bases. How could one ever observe if a multiple purpose tree production system would be, say, 0.1% more productive in terms of fuelwood supply? Or that such resource base can statistically serve 0.1% more end-use applications? If such data were known, the easy part would be converting them into $_{CO2}$ savings.
[3] RWEDP's activities aim to strengthen national and local ongoing efforts in wood energy development through conservation and sustainable management and utilisation of wood energy resources. For the purpose of the present study it may be acceptable to set a benchmark for RWEDP's contribution to wood energy conservation and resource development in the region. The benchmark could be put at, say, a modest 0.1% of current wood energy use. Translated into the household sector, this would imply that because of RWEDP's impact, one in 1,000 households in Asia would stick to an (improved) woodstove rather than switching to fossil fuel. In terms of numbers, the stated benchmark seems modest considering that (a) some 3,000 staff from various government and non-government organisations will have been trained in RWEDP's programme, and each trained staff can be expected to account for a certain multiplication factor during a number of years; (b) some 70,000 copies of wood energy related publications will have been distributed by RWEDP to institutional subscribers in Asia, and (c) already some 150 million improved wood stoves have been disseminated in RWEDP member-countries. The implications of woodfuel use for the global environment can be evaluated by estimating the associated greenhouse gas emissions. Only the main greenhouse gas, CO_2 (carbon-dioxide) will be considered here, leaving aside gases like methane and other carbon-hydrogens. Any emissions caused by woodfuels can be compared with emissions from alternative fuels.

Table 9.2. Detailed calculation of the implication of woodfuels on CO2 emissions in 16 RWEDP countries

Greenhouse gas effects of selected fuels			wood	LPG	electr-hydrc	electr-coal	kerosene	coal non-bit	fuel oil
CO2 non-biogenic	assumed	ton/PJ	-	65,440	1,833	293,944	69,980	87,000	73,730
CH4 (GWP =24.5 in 100y)	assumed	ton/PJ	-	1	-	4	-	1	1
N2O (GWP=320 in 100 y)	assumed	ton/PJ	-	-	-	-	-	-	-
	total	ton CO2eq	-	65,469	1,833	294,031	69,980	87,026	73,756
Source: LEAP Environmental Database									

			BAN	**BHU**	**CAM**	**CHI**	**IND**	**INS**	**LAO**	**MAL**	**MLD**	**MYA**	**NEP**	**PAK**	**PHI**	**SRI**	**THA**	**VIE**	**RWEDP**
share of households in WE consumption	assumed	%	93%	92%	92%	94%	90%	96%	92%	97%	92%	98%	97%	77%	88%	69%	91%	92%	92%
share of other uses in WE consumption	assumed	%	7%	9%	9%	6%	10%	4%	9%	3%	9%	2%	3%	23%	12%	31%	9%	9%	8%
Replacing fuels in household sector																			
typical conversion efficiency of wood stove	assumed	%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
market potential of LPG as replacement for wood	assumed	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
market potential of kerosene as replacement for wood	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of coal as replacement for wood	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of hydro/wind-electricity as replacement	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of coal-electricity as replacement for woc	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
typical conversion efficiency of LPG stove	assumed	%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
typical conversion efficiency of kerosene stove	assumed	%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	
typical conversion efficiency of coal stove	assumed	%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	
typical conversion efficiency of electrical stove	assumed	%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	
Replacing fuels in other sectors																			
typical wood energy conversion efficiency	assumed	%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
market potential of kerosene as replacement for wood	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of coal as replacement for wood	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of fuel oil as replacement for wood	assumed	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
market potential of hydro/wind-electricity as replacement	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
market potential of coal-electricity as replacement for woc	assumed	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
typical conversion efficiency of kerosene device	assumed	%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	
typical conversion efficiency of coal device	assumed	%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	
typical conversion efficiency of fuel oil device	assumed	%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	
typical conversion efficiency of electrical device	assumed	%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	

Table 9.2. Detailed calculation of the implication of woodfuels on CO2 emissions in 16 RWEDP countries (cont)

			BAN	BHU	CAM	CHI	IND	INS	LAO	MAL	MLD	MYA	NEP	PAK	PHI	SRI	THA	VIE	RWEDP
Estimated 1994 consumption of woodfuels	estimated	PJ/y	140.9	12.3	80.6	3,286.8	2,601.2	817.1	34.9	92.8	1.2	345.9	191.8	520.3	345.8	85.2	691.0	440.5	9,688.4
WE consumption in household sector	estimated	PJ/y	130.5	11.2	73.8	3,088.5	2,334.7	783.4	32.0	89.9	1.1	339.8	186.0	399.4	303.7	58.6	630.1	403.1	8,865.6
WE consumption in other sectors	estimated	PJ/y	10.4	1.0	6.9	198.4	266.5	33.7	3.0	2.9	0.1	6.1	5.8	120.9	42.1	26.6	61.0	37.4	822.8
in absence of woodfuels:																			
additional LPG consumption in hh sector	estimated	PJ/y	52.2	4.5	29.5	1,235.4	933.9	313.4	12.8	36.0	0.4	135.9	74.4	159.7	121.5	23.4	252.0	161.2	3,546.2
additional kerosene consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional hydro/wind-electricity consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal electricity consumption in hh sector	additional (	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional kerosene consumption in other sectors	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal consumption in other sectors	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional fuel oil consumption in other sectors	estimated	PJ/y	7.8	0.8	5.1	148.8	199.9	25.3	2.2	2.2	0.1	4.6	4.4	90.7	31.6	20.0	45.7	28.1	617.1
additional hydro/wind-electricity consumption in other sec	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal electricity consumption in other sectors	additional (	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2 avoidance through use of woodfuels																			
household sector	estimated	kton CO2	3,418	294	1,932	80,879	61,139	20,515	837	2,355	29	8,899	4,871	10,459	7,952	1,534	16,500	10,556	232,168
other sectors	estimated	kton CO2	577	58	379	10,972	14,743	1,865	164	159	6	336	322	6,689	2,329	1,473	3,373	2,071	45,515
total	estimated	kton CO2	3,994	352	2,311	91,852	75,882	22,380	1,001	2,514	34	9,234	5,192	17,148	10,281	3,007	19,873	12,627	277,683
1994 CO2 emission from fossil fuels	ORNL '97	kton CO2	18,338	150	487	2,836,068	839,437	235,888	293	91,538	106	6,359	1,419	80,521	44,420	5,174	130,904	26,039	4,317,142
CO2 avoidance through use of wood as % of present emmission		**%**	**22%**	**234%**	**474%**	**3%**	**9%**	**9%**	**342%**	**3%**	**32%**	**145%**	**366%**	**21%**	**23%**	**58%**	**15%**	**48%**	**6%**
Estimated 2010 consumption of woodfuels	estimated	PJ/y	199.8	17.9	113.3	3,792.3	3,385.9	1,012.0	52.4	123.2	1.9	467.7	275.7	782.5	454.9	101.5	800.9	591.3	12,173.2
WE consumption in household sector	estimated	PJ/y	185.0	16.4	103.7	3,563.4	3,039.0	970.2	48.0	119.4	1.7	459.5	267.3	600.6	399.5	69.8	730.2	541.0	11,114.9
WE consumption in other sectors	estimated	PJ/y	14.8	1.5	9.6	228.9	346.9	41.7	4.5	3.8	0.2	8.2	8.4	181.9	55.4	31.7	70.7	50.3	1,058.4
in absence of woodfuels:																			
additional LPG consumption in hh sector	estimated	PJ/y	74.0	6.6	41.5	1,425.4	1,215.6	388.1	19.2	47.8	0.7	183.8	106.9	240.3	159.8	27.9	292.1	216.4	4,445.9
additional kerosene consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional hydro/wind-electricity consumption in hh sector	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal electricity consumption in hh sector	additional (	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional kerosene consumption in other sectors	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal consumption in other sectors	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional fuel oil consumption in other sectors	estimated	PJ/y	11.1	1.1	7.2	171.6	260.2	31.3	3.3	2.9	0.1	6.2	6.3	136.4	41.5	23.8	53.0	37.7	793.8
additional hydro/wind-electricity consumption in other sec	estimated	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
additional coal electricity consumption in other sectors	additional (	PJ/y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2 avoidance through use of woodfuels																			
household sector	estimated	kton CO2	4,845	430	2,715	93,317	79,583	25,408	1,256	3,128	44	12,034	7,001	15,729	10,463	1,828	19,122	14,168	291,070
other sectors	estimated	kton CO2	817	84	533	12,660	19,190	2,309	247	211	9	454	462	10,060	3,064	1,755	3,909	2,780	58,545
total	estimated	kton CO2	5,663	514	3,247	105,977	98,773	27,717	1,503	3,338	53	12,488	7,463	25,790	13,527	3,583	23,031	16,948	349,615
assumed annual growth rates 1993-2000	UN-ESCAF	%/y	6.40%	6.40%	8.10%	6.50%	6.40%	8.10%	8.10%	8.10%	6.40%	8.10%	6.40%	6.40%	8.10%	6.40%	8.10%	8.10%	
assumed annual growth rates 2000-2010	UN-ESCAF	%/y	5.60%	5.60%	6.20%	4.90%	5.60%	6.20%	6.20%	6.20%	5.60%	6.20%	5.60%	5.60%	6.20%	5.60%	6.20%	6.20%	
2010 CO2 emission from fossil fuels	estimation	kton CO2	45,882	376	1,419	6,676,812	2,100,279	686,919	854	266,564	266	18,516	3,550	201,464	129,354	12,946	381,199	75,828	10,602,227
CO2 avoidance through use of wood as % of emmission from fos		**%**	**12%**	**137%**	**229%**	**2%**	**5%**	**4%**	**176%**	**1%**	**20%**	**67%**	**210%**	**13%**	**10%**	**28%**	**6%**	**22%**	**3%**

10. CONCLUSIONS & RECOMMENDATIONS

10.1 Conclusions

1. Wood energy is and will remain an important economic sub-sector in all RWEDP member-countries. The consumption of wood and other biomass fuels will increase in the foreseeable future. Non-forest land will continue to be the main source of woodfuels. Wood energy use is not and will not be a general or main cause of deforestation. Prime area of concern is not the availability of woodfuels *per se*, but rather their distribution to people in need. The weaker groups in society, particularly women and children, are the ones who suffer most from restricted access.
2. Aggregated for all the RWEDP member-countries, potential woodfuel supply exceeds woodfuel demand, both in 1994 and in projections for 2010.
3. In Bangladesh and Pakistan, as well as Nepal to some extent, present woodfuel demand may go to the limits of potential supply. By 2010 national shortages can be expected.
4. In India, Sri Lanka, Thailand and Vietnam, aggregate national consumption in 1994 is not limited by aggregate potential supply, but this may change by 2010.
5. In most other RWEDP member-countries, residues from forests and crops represent an under-utilised potential to supplement woodfuel.
6. 6.In all countries, localised woodfuel scarcities may occur in particular areas.
7. The key player for supplementing available woodfuels is the agricultural sector and enhancing woodfuel production on agricultural land can play a major part in increasing woodfuel supplies.
8. In areas and countries of woodfuel scarcity, other biomass fuels are likely to become complementary sources of energy.
9. As a first approximation it can be stated that woodfuel use is carbon neutral, i.e. there is no net emission of carbon into the environment.
10. Thanks to woodfuel use in Asia, the avoided environmental costs for recapturing CO_2 from the global atmosphere were at least 14 billion US$ in 1994, and will increase to 17.5 billion US$ in 2010.

10.2 Recommendations

1. The role of woodfuels produced in both forest and non-forest areas should be recognised, and treated as an important economic sub-sector requiring development.

2. Wood energy should be integrated into rural energy supply strategies and pursued as a common task for all relevant sectors, e.g. agriculture, forestry, rural development, energy and industry.

3. Woodfuel should be looked on as an important product in its own right, rather than just as a by-product of agricultural land. Integrated woodfuel production on agricultural land should be promoted.

4. Current efforts at reforestation and afforestation should be continued. Natural forest management, with popular participation, should get high priority in areas where woodfuel is not (yet) a tradable commodity.

5. Prevailing rules and regulations which hamper wood energy development should be reviewed and amended. These apply to: land ownership and holding, tree tenure, tree planting and harvesting in private and community lands, transportation and trade of wood and related products produced by the private sector or local communities.

6. Selection of fast-growing tree species for wood energy crops, identification of appropriate provenance to match specific conditions, and improvement of the survival and growth rate of trees at degraded sites and waste lands, should all be supported by further R&D.

7. Infrastructure should be developed further in areas where woodfuel is already a traded item and where potential exists for supply enhancement to meet the existing and growing market demand.

8. The good use of by-products and residues from wood industries should be encouraged in order to reduce wood waste and to supply additional fuels, in part by converting them into modern wood energy.

9. R&D for upgrading and combusting fuels from crop residues and other loose biomass should be promoted, for the use of households and of traditional industries.

10. More key data on wood energy supply should be collected to support wood energy policies.

11. Wood energy data bases should be established at regional, national and local levels. Private and public sector agencies related to wood energy development should be supported with information.

12. Wood energy subjects should be integrated into the training curricula of relevant sectoral education and training.

13. The priorities within wood energy conservation programmes should be the supply of convenient, healthy and attractive household stoves at affordable prices, so as to reach the maximum number of wood energy users.

14. The cost-effectiveness of projects for wood energy development in Asia in terms of global CO_2 savings should be communicated to interested donors agencies.

Box 5

About RWEDP

The Regional Wood Energy Development Programme in Asia (RWEDP, GCP/RAS/154/NET) is a long-term programme of FAO, funded by the Government of The Netherlands. Member-countries are Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam.

The development objective of RWEDP is to contribute to the sustainable production of woodfuels, their efficient processing and marketing, and their rational use for the benefit of households, industries and other enterprises.

The programme has the following three immediate objectives:

1) To contribute to an improved database on wood energy at regional and national level and to improve the capacity of institutions to generate, manage and assess such data at regional, national and sub-national level.

2) To contribute to the development and adoption of improved wood energy policies, plans and strategies in member-countries.

3) To improve the capabilities of government, private and community-based organizations in implementing wood energy strategies and programmes.

ANNEXES

ANNEX 1.

WOOD & BIOMASS ENERGY IN THE ASIA - PACIFIC REGION

Overview of available data and database systems on wood and biomass energy and "best" estimate of the future demand in the Asia-Pacific region

A1.1 Introduction

This paper provides an initial and preliminary overview of available data on energy use including wood and biomass energy within the Asia-Pacific region. Using the information contained in the various sources discussed in the paper (databases, etc.), attempts have been made to present a "best" estimate for the use of wood and biomass energy use at present as well as for the near future within the Asia-Pacific Region. This has been done by selecting those sources of information which are expected to "best" represent the actual situation.

The main objectives of the report are a) to present an overview of available information on wood/biomass energy and b) to serve as a basis for making predictions on the consumption of wood/biomass energy in the near future such as for instance is required for the Asia-Pacific Forestry Outlook Study which is being prepared by FAO. The latter is expected to provide some insights into fuelwood use in relation to forests and forest products up to the year 2010. The following steps have been taken to fulfil the main objectives as stated:

- Provision of an overview of database systems on energy use and definitions used by these database systems;
- Comparing the advantages and disadvantages of the main database systems;
- Drawing conclusions with regard to the reliability of data and database systems on wood/biomass energy use.
- Selecting those sources which are expected to "best" represent the actual situation;
- Present a very preliminary estimate on wood and biomass energy use in the near future.

A1.2 Analysis of Available Database Systems and Definitions Used with Regard to Woodfuels and Other Biomass Energy Sources

Unlike for instance in other regions such as Europe where the UN-ECE, EUROSTAT and OECD/IEA are jointly active in data collection and analysis[1], the situation in the Asia-Pacific region with regard to data on energy use is more fragmented. This is particularly true for biomass energy. Within the Asia-Pacific Region, the Asian Development Bank (ADB) based in Manila, the Philippines, the Asia Pacific Energy Research Center (APERC) based in Tokyo, Japan and the ASEAN-EC Energy Management and Training Center (AEEMTRC) based in Jakarta, Indonesia are some of the regional organizations involved with energy related data, etc. Moreover, international organizations such as the United Nations, FAO and IEA of the OECD also collect data on energy use, etc. A brief description of the various database system follows:

ADB The Asian Development Bank collects and analyses data on energy use for their developing member countries (40 in the Asia and Pacific region). At present this is limited to the conventional energy sources and conversion processes e.g. oil, gas, coal and electricity. Biomass energy is not covered.

APERC Likewise, the Asia Pacific Energy Research Center based in Tokyo, Japan collects and analyses energy related data for their member countries e.g. the Asia-Pacific Economic Cooperation (APEC) countries which are roughly those countries which border the Pacific Ocean (Asia, North and South America and Oceania). Unfortunately, their database does not yet include biomass energy data although there are signs that these will be included in the near future. At present (first half of 1997) a limited amount of data for only 2-3 countries have been published (Personal communication, 1997a; HTTP://www.ieej.or.jp).

AEEMTRC The ASEAN-EC Energy Management and Training Center collects and analyses data on energy use including biomass energy for 7 ASEAN countries. However, the data on biomass energy published during previous years (ASEAN Energy Review 1993 and 1994) appear to be based on secondary data from several years back and can be considered unreliable (Personal communications, 1997c).

UN The United Nations collects and analyses both conventional and traditional energy sector for their member countries which include almost all countries in the Asia and Pacific region. See A1.2.2.

FAO The Food and Agriculture Organization collects data on fuelwood and charcoal only within the framework of their database system on forest products. The database system includes data on all their member countries including almost all countries in the Asia and Pacific region. See A1.2.1.

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[1] *These organizations jointly collect information by using a set of four questionnaires which are sent to key organizations in the respective countries in the region. Information on woodfuels and biomass is collected using the "Annual Questionnaire on Solid Fuels, Wastes and Manufactured Gases".*

IEA The International Energy Agency (IEA) of OECD collects and publishes data on energy use both for conventional as well as traditional sources of energy (3 countries in Asia and the Pacific). Some of the non-OECD countries are covered as well but this is limited to conventional sources of energy. Since 1993 traditional sources of energy have been covered as well but only for those countries where data are available (6 countries in Asia and the Pacific). See A1.2.3.

WRI The World Resources Institute publishes data on energy use (conventional as well as traditional sources of energy). See A1.2.4.

EIA The U.S. Department of Energy (DOE) collects and publishes data on energy use through the Energy Information Administration (EIA) for almost all countries in the world. Unfortunately, this is generally limited to conventional sources of energy with the exception of the USA for which renewable sources of energy, including wood and biomass, are also presented. See A1.2.4.

Besides these institutions and organizations there are also a few other sources of information on energy use within the region. These database systems are mainly based upon original country data such as those published by energy, forestry and/or statistical organizations of the countries concerned. Use has been made of these sources in those cases where information was available to the Association for Energy Development Planning – Asia (Personal communication, 1997b)[1].

As indicated earlier, this paper will also be used as a background paper by the Regional Wood Energy Development programme of FAO for the Asia-Pacific Forestry Outlook Study. The latter aims to provide an overview of forestry related topics in the Asia-Pacific region including the state and importance of the forests, forest industries, etc. both at present as well as providing an outlook for the near future. For that reason a decision was made to cover the 30 countries which also appear in the "Selected Indicators of Food and Agriculture Development in the Asia-Pacific Region" published on an annual basis by FAO-RAP (for example: FAO, 1995a). However, the information presented in the paper can also be used for other purposes e.g. other than those directly related to forests.

The 30 countries have been divided into four main groups i.e. The 16 RWEDP member countries, (Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Maldives, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam), Other Asia (Iran, Korea PDR, Korea Rep. and Mongolia), the Pacific (Cook Islands, Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu) and finally those countries which are OECD/IEA members (Australia, Japan and New Zealand).

Given the context of this paper i.e. wood and biomass energy, only those database systems have been included which cover these countries and which include these sources of energy. These basically concern the FAO database (fuelwood and charcoal only), the UN (conventional and traditional sources of energy) and the IEA (conventional and traditional sources of energy) and the EDP-Asia database (conventional and traditional sources of energy). The following briefly describes these four database systems, the definitions used by the various organizations for the traditional sources of energy and their merits and de-merits as perceived by the author.

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[1] These are referred to as the database of EDP-Asia. The latter, which is a not-for-profit organization of independent consultants, collects and stores information on both conventional and traditional sources of energy consumed by countries in the Asia-Pacific region. Unfortunately, those data are not published but their sources can be accessed upon request.

A1.2.1 FAO Forest Product Yearbook

As indicated above, the FAO Forestry database contains data on fuelwood and charcoal only. The information is published annually in the Forest Products Yearbook and is available through the Internet as well (FAO, 1993a, 1995c, 1996a; HTTP://apps.fao.org/). The data on fuelwood and charcoal are part of an extensive overview of production figures on various types of forest products.

Method of Data Collection

Data are collected by means of annual questionnaires sent to country contact points (normally the Forest Ministry/Department/Agency) in those countries which are members of the UN family. This information is shared by FAO and the UN. Apparently Europe (EUROSTAT) also uses the same information. The sharing of information is carried out to ensure that compatible databases are created and money saved by combining forces. In this way too, country contact points are only asked once to provide the information.

As part of total removals from the forests, data on fuelwood (including wood used for charcoal) are requested. This is disaggregated into coniferous and non-coniferous wood. Moreover, information on charcoal production as well as trade in both charcoal and fuelwood is requested.

Neither in the questionnaire nor in the yearbook, is an explicit definition given for "fuelwood". The FAO Internet site[1] where statistical data can be accessed, defines fuelwood as:

> *"Wood in the rough (from trunks, and branches of trees) to be used as fuel for purposes such as cooking, heating or power production. The commodities included are fuelwood, coniferous and non-coniferous wood and the roundwood equivalent of charcoal".*

The Forest Products Yearbook which is published annually gives a much less qualified definition for fuelwood. However, as fuelwood is considered as being part of "roundwood", the definition of fuelwood can be further defined using the definition of roundwood as well (in addition to the definition as given on the Internet) as:

> *"It comprises all wood obtained from removals i.e. the quantities removed from forests and from trees outside the forests including wood recovered from natural, felling and logging losses. The statistics include recorded volumes as well as estimated unrecorded volumes."*

Charcoal is defined on the FAO-Internet site as:

> *"Wood carbonised by partial combustion or application of heat from an external source. It is used as a fuel or for other uses".*

[1] *Internet address: HTTP://APPS/FAO.ORG*

However, the Forest Products Yearbook defines charcoal as:

> *"Wood in the rough (from trunks and branches of trees) to be used as fuel for purposes such as cooking, heating or power production. Wood for charcoal, pit kilns and portable ovens is included".*

Data on "Fuelwood + Charcoal" are also given with the note that the data include the roundwood equivalent of charcoal, using a factor of 6.0 to convert from weight (Metric Tons) to solid volume units (cubic meter).

It appears that these definitions for fuelwood implicitly exclude woody residues from industrial processing (saw dust, off-cuts, etc.) as well as recovered/recycled products such as wood obtained from the demolition of buildings, packing crates, pallets, etc.

Structure and Reliability of the Database

The Forest Products Yearbook as well as the FAO Internet site give an overview for the production and trade of all forest products including fuelwood and charcoal for all UN member countries. Unfortunately, with regard to the Asia-Pacific region all production figures for fuelwood and charcoal, with very few exceptions, are based on estimates by FAO. These estimates are in the first instance made by repeating the figures of the years in which data were given. If no data are available (which is the case for almost all Asia-Pacific countries), estimations are made on the basis of assumed average per capita consumption figures of fuelwood which are multiplied with the number of inhabitants of the country under consideration (FAO, 1997a). These average per capita consumption figures have in many cases not changed since 1961, the first year for which data are available.

The data given are highly aggregated and are limited to production and trade e.g. they do not include information on end-use such as for the domestic sector, industrial sector, etc. However, as estimates are based on per capita consumption figures, it may be assumed that only the domestic sector is included. This assumption is strengthened by the fact that industrial wood residues apparently are not included (saw mill, plywood, etc.) nor black liquor from pulp production based on wood as a raw material, etc.

No distinction is made with regard to the source of wood (forest or non-forest based or direct or indirect forest wood or inventoried or non-inventoried sources). The latter distinction, inventoried or non-inventoried, is based on the state of the forest having been assessed (normally in the form of area and standing stock - bole volume) while non-inventoried sources include all other types e.g. lops and tops from forest trees (these residues are normally not considered while measuring standing stock) as well as trees outside the forest. Production figures for fuelwood are given in cubic meters solid volume (cum) while those for charcoal are presented in metric tons.

Advantages and Disadvantages of the FAO Database on Woodfuels

The FAO database has the advantage that basically all countries which are members of the UN system are included (data are available for 27 out of the 30 countries covered – not covered are the Maldives, Cook Islands and Tonga). Data is given for both fuelwood and charcoal production, imports and exports and is published annually. Data for exports and imports are given both in weight/volume as well as value. Time series data over a period of more than 30 years are available both in printed and electronic form.

The drawback of the database is that only woodfuels are covered (no information on conventional sources of energy, no information on other renewable sources of energy). Most of the data are based on estimates for per capita energy consumption which estimates, in most cases, have not changed over the last 30 years. In addition, wood residues generated by wood based industries such as sawmilling, plywood production, etc. as well as recycled wood apparently are not included. The reliability of the data in terms of covering all wood and biomass energy use is therefore in doubt. Besides, the data are highly aggregated e.g. no distinction is made with regard to end-users nor is a distinction being made with regard to the source of the woodfuels.

A1.2.2 United Nations

The United Nations provides information on energy in the “Energy Statistics Yearbook” and in “Energy Balances and Electricity Profiles”. The publication of energy data commenced with “World Energy Supplies in Selected Years 1929-1950” published in 1952. The present publications, published every two years, give information over the last four years and contain updated information published in previous issues (UN, 1990 a and b, 1992 a and b, 1994 a and b, 1995, 1996). The principle objective of the UN is to provide a global framework of comparable data on long-term trends in the supply of mainly commercial primary and secondary forms of energy. Definitions used by the UN for fuelwood and charcoal are basically the same as those used by FAO but appear to be less descriptive as shown in the following definitions:

> *“Fuelwood refers to all wood in the rough used for fuel purposes[1].”*
>
> *“Charcoal is a solid residue consisting mainly of carbon obtained by the destructive distillation of wood in the absence of air.”*
>
> *“Bagasse refers to the cellulosic residue left after sugar is extracted from sugar cane. It is often used as a fuel in the sugar industry.”*
>
> *“Animal wastes are defined as dung and other non-dried excreta of cattle, horses, pigs, poultry and the like and, in principle, humans, used as a fuel.”*
>
> *“Vegetal wastes are mainly crop residues (cereal straw from maize, wheat, paddy rice, etc.) and food processing wastes (rice hulls, coconut husks, ground nut shells, etc.) used for fuel. Bagasse is excluded.”*
>
> *“Other wastes refer all forms of energy not specifically defined above, such as municipal wastes and pulp and paper wastes.”*

[1] Production data include the portion used for charcoal production using a factor of 6 to convert from weight basis to the volumetric equivalent of charcoal. Judging from the definition used. Fuelwood apparently does not include waste wood from wood processing industries, recovered and/or recycled wood, etc.

Method of Data Collection

Data are compiled primarily from annual questionnaires distributed by the United Nations Statistical Division and supplemented by official national statistical publications. Where official data are not available or are inconsistent, estimates are made on other sources which include but are not limited to partial year information, use of annual trends, breakdown of aggregated data as well as analysing current energy activities. Other sources of information include data compiled by IEA-OECD, FAO, OPEC, EUROSTAT, WEC, International Sugar Organization, etc.

Structure and Reliability of the Database.

As mentioned earlier, UN has two types of published statistical outputs. The “energy balances” give data series for various countries using energy units[1] (UN, 1990b, 1992b, 1994b, 1995. Wood and charcoal are presumably included here in the aggregated item of “Primary biomass” and “Derived biomass”. It does include data on production, transformation and sectoral consumption The “energy statistics” publication gives information mainly in the form of commodities. This gives a higher level of disaggregation and presents the data in their original units (e.g. ton, m^3, litres, etc.) However, no differentiation is made with regard to end-users.

With regard to biomass energy, use is made of the data on fuelwood and charcoal as provided by FAO. An exception are the following countries in the Asia-Pacific region: Bangladesh, Bhutan, Japan, Nepal, Republic of Korea, Sri Lanka and Thailand where the information is provided through the questionnaires or through official publications. Besides fuelwood, bagasse is also covered where in most cases use is made of sugar production data provided by the International Sugar Organization based in London. Calculations for the amount of bagasse is based on a method developed by the Economic Commission for Latin America (ECLAC) which assumes that for each ton cane sugar produced about 3.26 metric tons of fuel bagasse are produced having a moisture content of 50%.

The Energy Statistics Yearbook gives information on a selected series of statistics on fuelwood, charcoal and bagasse for almost all Asia-Pacific countries (UN, 1990a, 1992a, 1994a, 1996). It is not clear if this concerns production and/or consumption. The “Energy Balances and Electricity Profiles” provides information on the production, conversion, consumption as well as export/import of primary and derived biomass for the following Asia-Pacific countries: Bangladesh, China, India, Indonesia, Malaysia, Myanmar (from 1991 onwards), Nepal, Pakistan, Philippines (discontinued after 1992), Sri Lanka, Thailand as well as Korea (Rep.), Fiji, Papua New Guinea and the Solomon Islands (discontinued after 1992). With regard to end-use in the industrial sector, for most countries this appears to cover only bagasse.

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1 Like the IEA, the UN also uses country specific calorific values for most of the conventional sources of energy. For biomass energy the following conversion factors are used as specified in the UN Energy Statistics Yearbook – fuelwood – 1 cu m equals 0.333 ton coal equivalent (tce), charcoal – 1 ton equals 0.986 tce and bagasse – 1 ton equals 0.264 tce. A ton coal equivalent is equal to 29.3076 GJ, while 1 tce is equal to 0.7 toe. 1 toe therefore equals 41.868 GJ. However, the UN Energy Balances and Electricity Profiles defines 1 toe as being equal to 42,6216 GJ. The difference is probably based on the fact that 1 toe originally was defined as the heating value of 1 ton of crude oil with a specific gravity of 0.86. This resulted in a value of 0.1018 TCal. for one toe. However, other organizations, notably EUROSTAT used a factor of 0.1 TCal (equal to 10,000 kCal per kg.) and in 1978 the UN Statistical Office decided to follow suit. However, the “old” conversion factor apparently is still used in the UN Energy Balances and Electricity Profiles for reasons unknown.

Advantages and Disadvantages of the UN Database on Woodfuels

The UN database covers both conventional and traditional sources of energy. It has, like the FAO database, the advantage that time series are available for most countries. Such information is readily available in printed form and can upon request also be supplied on tape or diskette.

Unlike the FAO database system, a distinction has been made between end-use categories (e.g. industries, transport, domestic and other use, etc.). For the industrial sector the distinction is not very detailed in the sense that several ISIC codes for industries are grouped together. The information is published bi-annual but does not cover all countries.

A major disadvantage is that the information is generally highly aggregated. “Primary Biomass Energy” includes wood as well as bagasse and possible other sources of biomass as well while “Derived Biomass” includes charcoal and possibly other types (black liquor, ethanol, etc.). In many cases the data on wood and charcoal are based on data obtained from FAO (see the section on the FAO database for the pros and cons). No distinction is being made with regard to the source of biomass.

A1.2.3 IEA Energy Statistics

The data on wood and biomass based energy of the IEA ultimately have to fit into the structure of their energy balances. These energy balances are the main basis for modelling and forecasting work that is undertaken within IEA. For this purpose it is essential that data are available in the form of time-series, that a clear definition of the various types of wood is available (based on their inherent quality and type - solid - liquid - gas) and that information on sectoral consumption is according to the (ISIC based) system used also for all conventional fuels. Combustible renewables and wastes are sub-divided into four main categories e.g (IEA 1996c):

> *“Solid biomass and animal products: Biomass is defined as any plant matter used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes and sulphite lye, also known as “black liquor.”*
>
> *“Gas/Liquids from biomass: Gases derived principally from anaerobic fermentation of biomass and solid wastes and combusted to produce heat and/or power. It includes landfill gas, biogas (gas from animal slurries) and sludge gas (sewage gas). Bio-additives such as ethanol are also included in this category”.*
>
> *“Municipal waste: Consists of products that are combusted directly to produce heat and/or power and comprises wastes produced by the residential, commercial and public service sectors that are collected by local authorities in a central location. Hospital waste is included in this category.”*
>
> *“Industrial waste: Consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants to produce heat and/or power.”*

Method of Data Collection

Information requirements on combustible renewables which includes wood and charcoal is included in the IEA questionnaire on Solid Fuels, Wastes and Manufactured Gases, which is a joint questionnaire together with UN-ECE and, since 1995, EUROSTAT (FAO, 1997a).

Before 1995, all biomass was included in the category “other solid waste”, which also included peat, municipal solid waste and industrial waste. In the new questionnaire, production, transformation and final consumption data are asked for “solid biomass and animal products” while steps are being undertaken to include in the near future data on “Combustible Renewables and Wastes”. The latter is planned to be disaggregated into “Solid Biomass and Animal products”, “Gases from Biomass and Wastes”, “Liquids from Biomass and Wastes”, “Industrial Wastes”, Municipal Wastes”, “Non-specified Combustible Renewables and Wastes” and “Charcoal” (Kousnetzoff/Denman - Personal Communication). Wood is expected to be divided into “Wood (gathered explicitly for fuel use)”, “Wood waste (sawdust, shavings, chips, bark, etc.)“, “Forest residues (logging residues, tops, etc.)” and “Other wood waste (recovered wood, etc.)”. The last three types are included under the sub-heading “Vegetal Waste”. Box A1 provides an overview of the planned disaggregation of the various wood and biomass energy sources.

Structure and Reliability of the Database.

For OECD countries, IEA has two types of published statistical outputs. The “energy balances” are the most aggregated as regards types of energy sources, but presents all data in energy units[1] so that the whole system of production, transformation and supply is in balance (IEA, 1996b). Wood is included here in the aggregated item of “combustible renewables and waste”. Australia, Japan and New Zealand are included from the Asia-Pacific Region.

The other publication is in the form of commodity balances e.g. “basic energy statistics”. This gives a higher level of disaggregation and presents the data in their original units (e.g. ton, m^3, litre’s, etc.) (IEA, 1996a). It does include the production, transformation and sectoral consumption. The main item “combustible renewable and waste” is split up into “solid biomass and animal products”, “gas/liquids from biomass”, “municipal solid waste” and “industrial waste”.

The item “solid biomass and animal products” is further disaggregated in the database itself into “wood”, vegetal waste (including the share of “wood waste”), “black liquors” and “other solid biomass”. Only production figures are included.

Questionnaires are sent to official national administrations which have some kind of government connection, because IEA members are obliged to answer the questionnaire. These institutes, however, are often not very familiar with wood or biomass in general so responses on these items are relatively poor (Personal communication, 1997c).

Since 1996 IEA has made considerable efforts to improve the quality of the biomass data by discussing them intensively with the various countries.

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[1] *IEA converts energy sources by using the lower heating value of fuels. For the conventional sources of energy in many cases country specific values are used. For biomass no specific calorific values are given. In the “Energy Balances” amounts are expressed in Tons of Oil Equivalent using a factor of 41.868 GJ per toe.*

Box A1
Definition of Combustible Renewables and Wastes, as Proposed by IEA

Information on wood and biomass fuels collected by the IEA. Products shown as bold are presented in IEA publications (except charcoal).

Solid Biomass and Animal Products

- Wood (gathered explicitly for fuel use) (from UN: Fuelwood refers to all wood in the rough used for fuel purposes. Production data include the portion used for charcoal production.)
- Vegetal material and waste (from UN: mainly crop residues and food processing wastes used for fuel. Bagasse is excluded.)
  - ♦ Wood waste – Includes sawdust, chips, shavings, bark, etc.
  - ♦ Forest waste – Includes logging residues, tops, etc.
  - ♦ Other Wood Wastes
  - ♦ Sugarcane bagasse – (from UN: the cellulosic residue left after sugar is extracted from sugar cane.)
  - ♦ Rice/paddy husks
  - ♦ Coconut shells, fibre, pith
  - ♦ Maize cobs and stalks
  - ♦ Groundnut husks (includes peanuts)
  - ♦ Coffee husks
  - ♦ Wheat stalks and husks
  - ♦ Cotton stalks and waste (includes gin trash)
  - ♦ Mustard stalks and waste
  - ♦ Other straw
  - ♦ Olive pressing waste
  - ♦ Other vegetal material and waste
- Black liquor
- Animal products (from UN: Animal wastes refer to dung and other non-dried excreta of cattle, horses, pigs, poultry and the like, and, in principle humans. It can be dried and used directly as a fuel or converted to methane methods of fermentation or decomposition.)
  - ♦ Dung
  - ♦ Other animal products
- Other solid biomass and animal products

Gases from Biomass and Wastes

- Landfill gas
- Sludge and sewage gas
- Other gases from biomass and wastes

Liquids from Biomass and Wastes

- Alcohols (ethanol, methanol, etc.)
- Bio-additives (e.g., from oleaginous plants)
- Other distilled liquids from biomass & wastes
- Cane liquor
- Molasses
- Other non-distilled liquids from bio & wastes

Industrial Waste

Municipal Waste

Non-specified (primary product)

Charcoal (a secondary product)

Information for non-OECD countries are provided by the countries themselves on a voluntary basis i.e. through publications from the countries concerned, visits, etc. Where available, the information is disaggregated with regard to end-use e.g. by industrial-, domestic- and other sectors. For 1993-1994 information on biomass energy was only available for the following Asia-Pacific countries: China, Indonesia, Korea (Rep.), Nepal, Philippines and Thailand (IEA, 1996c).

Advantages and Disadvantages of the IEA Database on Woodfuels

The IEA database has the advantage that both conventional as well as renewable sources of energy are included. Besides, the information on combustible renewables, which include fuelwood, is largely based on data provided by the countries themselves. It may therefore be assumed that the reliability of the data is generally quite good. The database gives disaggregated information on production, conversion as well as end-use. For the OECD countries data on secondary sources of woodfuel e.g. black liquor as well as other wastes including municipal waste, etc. are given. The data is made available on an annual basis in printed form and can also be obtained in electronic form.

The disadvantage of the database is that the information on combustible renewables is aggregated e.g. wood forms part of combustible renewables. Wood based fuels are disaggregated to a certain extent only for the three OECD countries in the Asia-Pacific region. The other disadvantage is that for the non-OECD countries information is at present only available for 1993 and 1994 i.e. no time series data are available. For the three OECD countries information over a longer period is generally available. Even though the data is aggregated, the information, depending on the country, may be available in a disaggregated form. Such information is normally not published but can be made available upon request (Denman, personal communication).

A1.2.4 Other Sources Including EDP-Asia

Besides the databases described, other sources of information are available. One is the World Resources Institute which publishes time series data for conventional as well as traditional sources of energy (WRI 1995, 1996a and b). As the data appear to be based on the UN/FAO database systems, the same advantages and disadvantages apply e.g. almost all countries covered, time series data available but information on fuelwood covered under traditional energy (no disaggregation). Unfortunately, WRI apparently has stopped including new data on traditional energy (as the data for 1991 were repeated in 1992 and 1993). Besides, no distinction is made with regard to end-use sectors. This source of information has therefore not been used.

Other sources are information provided by the countries themselves (statistical publications, etc.) or through other publications such as Asian Energy News published by CEERD-AIT (AIT, 1995), studies carried out by the World Bank (ESMAP program), etc. In most cases the data are disaggregated both in terms of source (fuelwood, charcoal, residues, etc.) and end-use sector. This is a clear advantage over the UN system databases such as the UN and FAO. However, in most cases no time series data are available with the exception of Nepal and Thailand which publish an annual energy balance which includes biomass energy in disaggregated form. The information is published by various national organizations in the countries concerned or by other (international) organizations directly involved with specific country studies. Getting access to such information is sometimes difficult due to their scattered nature and/or a lack of knowledge with regard to their existence. EDP-Asia, which is a not-for-profit organisation based in the Netherlands and has at present offices in Thailand and Vietnam is making use of these sources of information described above. EDP-Asia has an interest in both conventional and traditional sources of energy.

The advantages of the EDP-Asia database is that their database is relatively easy to access, the data are to a greater or lesser extent (depending on the country) disaggregated by source as well as by end-user. As data are generally obtained direct from the countries or indirectly through specialised agencies such as the World Bank-ESMAP, Forest Master Plan studies, the accuracy of the data can be assumed to be reasonably good. However, the disadvantage is that in most cases no time series data are available and that conversion factors from original units to energy units are often not available. Another major disadvantage is that definitions for the different types of woodfuels and biomass energy are not available as in almost all cases these are not published by the countries concerned. This may be a reason why information for some countries from different sources shows differences. However, at the same time it should be noted that even when the same source is used, considerable differences can sometimes be observed in the data[1].

[1] *Examples of the latter are for instance Vietnam where the World Bank in two different publications arrives at two completely different values for biomass energy use - 1990 and 1992 data for agro-residues use differ by a factor of 10. After analyzing this it appears that the 1990 numbers are far too low as the accompanying text indicates that agro-residues use should be far higher. Another case are statistics published by the Central Statistical Office in Indonesia on energy use. For the 1986-1990 period the amount of biomass shown is a factor of 10 lower than that in other tables in the same publication on fuelwood and charcoal use indicate.*

A1.3 “Best” Estimate for Wood/biomass Energy Use

Considering the results of the overview presented in the previous chapters it is clear that there are quite a few differences in the different database systems not only with regard to the amount and reliability of the data but also with regard to the definitions used for the different types of woodfuels and biomass energy used. In particular, further efforts are required to get a better overview of the sources of woodfuels (forest, non-forest, processing residues and recovered/recycled wood) in relation to overall wood energy consumption. The same is true for other types of biomass. With regard to definitions, concerted efforts are being made to come to some form of a unified approach for definitions to be used by all parties concerned. Final results of this undertaking may take some time to materialise[1]. However, this is only the first step. The next step will be to ensure that data collected will be disaggregated according to the new definitions and probably more important to disaggregate the information according to source. Although IEA appears to be have set the first steps in this direction as is evident from the type of information they collect (see box A1), still further improvements are possible in particular with regard to “wood” for which no distinction is being made with regard to source e.g. forest and non-forest. Other organizations still have a long way to go in this direction.

Table 1 gives an overview of the number of records for the 30 countries for the period 1981-1994 which are currently available in the four different systems discussed here. These records (expressed in Petajoules) are shown in appendix 1 which gives an overview of the data on woodfuel and biomass energy consumption in the 30 countries concerned.

The sheets 1-3 of appendix 1 provide information on woodfuel use, the sheets 4-6 show the information on biomass energy use. FAO has only data on woodfuels and is therefore not included in the sheets 4-6. Likewise, the UN database has data on biomass energy (woodfuel is included under the heading “biomass”) and is therefore not included in the sheets 1-3 of appendix 1.

Appendix 2 sheet 1-6 show the woodfuel and/or biomass energy share in % of the total energy consumption for each of the main database systems (FAO, IEA and EDP-Asia for woodfuels and UN, IEA and EDP-Asia for biomass energy including woodfuels). For ease of comparison the last three years for which data are generally available (1992-1994) have been reproduced in Table 2.

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[1] FAO has initiated activities in this field. However, although everyone agrees that there is a need for standard definitions, not everyone seems to agree that there is a need for a “new” set of definitions as this most probably would entail a complete overhaul of existing database systems.

Table 1. No. of records available for 1980-1994 in the four database systems							
		Woodfuels			Biomass		
		FAO	IEA	EDP-Asia	U.N.	IEA	EDP-Asia
	ASIA-RWEDP						
1	Bangladesh	15	0	2	10	0	2
2	Bhutan	15	0	1	0	0	1
3	Cambodia	15	0	1	0	0	1
4	China	15	0	4	6	2	5
5	India	15	0	0	10	0	0
6	Indonesia	15	0	9	10	2	9
7	Laos	15	0	1	0	0	1
8	Malaysia	15	0	0	10	0	0
9	Maldives	0	0	2	0	0	2
10	Myanmar	15	0	8	4	0	8
11	Nepal	15	0	14	10	2	14
12	Pakistan	15	0	1	10	0	2
13	Philippines	15	0	0	8	2	1
14	Sri Lanka	15	0	0	10	0	3
15	Thailand	15	0	11	10	2	11
16	Viet Nam	15	0	2	0	0	2
	ASIA-OTHER						
17	Iran, Islamic Rep	15	0	0	0	0	0
18	Korea DPR	15	0	0	0	0	0
19	Korea Rep.	15	0	0	10	2	2
20	Mongolia	15	0	0	0	0	0
	PACIFIC						
21	Cook Islands	0	0	0	0	0	0
22	Fiji	15	0	1	10	0	1
23	Papua New Guinea	15	0	1	10	0	2
24	Samoa	15	0	1	0	0	1
25	Solomon Island	15	0	1	8	0	1
26	Tonga	0	0	0	0	0	1
27	Vanuatu	15	0	1	0	0	1
	OECD Members						
28	Australia	15	8	8	0	15	15
29	Japan	15	2	0	0	3	3
30	New Zealand	15	8	8	0	15	15

Table 2. - Comparison of various data sources with regard to woodfuels and/or biomass

WOODFUEL AND BIOMASS/RENEWABLE ENERGY CONSUMPTION IN PJ																			Source: EDP-Asia Database	
		FAO Woodfuels			IEA Woodfuels			EDP Woodfuels			UN Biomass			IEA Combustible Renewables			EDP Biomass			Remarks
		1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	
	ASIA-RWEDP																			
1	Bangladesh	283.4	289.7	296.1				115.0			343.1	342.3	337.8				504.0			EDP-1990 data
2	Bhutan	12.7	12.8	12.9																
3	Cambodia	59.4	61.2	63.0						80.7									87.8	
4	China	1,897.1	1,934.9	1,973.6				3,281.0		3,290.0	2,094.6	2,123.0	2,121.0		7,230.6	7,259.5	7,337.5	7,360.8	7,389.7	
5	India	2,507.2	2,555.3	2,603.4							2,881.5	2,876.7	2,929.1							
6	Indonesia	1,396.5	1,418.8	1,440.2				787.3	797.0	817.9	1,468.6	1,494.7	1,515.3		1,111.3	1,111.3	787.3	797.0	817.9	
7	Laos	40.0	41.1	42.4				34.0									34.0			EDP-1990 data
8	Malaysia	88.6	90.7	92.9							91.1	93.3	95.5							
9	Maldives							1.1		1.2							1.1		1.2	
10	Myanmar	181.3	191.0	193.8				343.8	345.0		185.9	195.7	198.6				343.8	345.0		
11	Nepal	180.9	185.7	190.5				180.6	183.9	192.0	218.5	222.1	228.9		255.3	261.6	240.4	246.2	256.1	
12	Pakistan	247.7	257.0	265.2						520.8	303.6	313.4	326.5					911.0	918.2	
13	Philippines	331.8	339.0	346.1							387.3				498.6	498.6			507.6	
14	Sri Lanka	83.2	84.2	85.3							89.4	92.2	95.0				173.6			
15	Thailand	342.2	345.9	349.4				588.8	647.0	691.7	679.1	759.6	803.4		742.2	810.9	693.9	755.7	825.9	
16	Viet Nam	275.7	282.0	288.3				423.0									815.8			
	ASIA-OTHER																			
17	Iran, Islamic Rep	24.4	24.5	24.7																
18	Korea DPR	40.5	40.9	41.4																
19	Korea Rep.	43.4	43.4	43.4							43.9	43.9	43.9		31.1	37.9			38.6	
20	Mongolia	3.5	3.6	3.6																
	PACIFIC																			
21	Cook Islands																			
22	Fiji	0.4	0.4	0.4							11.7	11.7	14.0							
23	Papua New Guinea	53.5	53.5	53.5				23.0			59.7	59.7	59.8				30.0			EDP-1990 data
24	Samoa	0.7	0.7	0.7																
25	Solomon Island	1.3	1.3	1.3							3.2									
26	Tonga																			
27	Vanuatu	0.2	0.2	0.2																
	OECD Members																			
28	Australia	28.0	28.0	28.0	96.5	99.5	101.7	90.4	92.9	93.4				164.5	181.7	188.8	164.5	181.7	188.8	IEA woodfuel
29	Japan	3.7	3.5	3.5		153.5	150.5							92.1	184.6	181.3	92.1	184.6	181.3	data includes
30	New Zealand	0.5	0.5	0.5	40.7	42.1	42.1	26.1	27.5	27.5				41.0	42.7	42.7	41.0	42.7	42.7	black liquor

Tables 1 and 2 as well as the appendices indicate that the FAO database with regard to woodfuels is by far the most complete while the IEA database is the least complete. The latter is not surprising as data for non-OECD countries have been published only since 1993 and information on combustible renewable sources of energy is available only for a few of these countries. IEA does not yet publish or does not yet have data on woodfuel use for these or for the other countries.

In between those two are the UN and the EDP-Asia database systems. Both are more or less comparable with regard to completeness. However, the EDP-Asia database contains both information on woodfuels and biomass energy and in that way can be considered as being more desirable than the UN database system[1]. Both database systems have to a certain extent disaggregated data with regard to end-users[2].

However, when the numbers in terms of energy consumption are considered, it appears that both the FAO and the UN database systems, with the exceptions of Indonesia, Korea Rep. and Papua New Guinea, show far smaller consumption data for wood and biomass energy than the IEA and EDP database systems. The latter two systems use data based on information supplied by the countries themselves while the FAO and UN database systems often use estimates. The FAO and UN database systems appear to be linked as UN makes in many cases use of FAO data for woodfuel use. To this they add bagasse (which is not included in the FAO database), assuming that all bagasse is used as a source of energy.

The IEA and the EDP-Asia databases are also linked to a certain extent as EDP-Asia makes use of IEA data for those countries where they themselves do not have information (mainly the OECD countries). The slight differences between the IEA and the EDP-Asia database for the OECD countries are caused by the fact that the EDP-Asia database does not include black liquor in woodfuels while in the IEA database these are included.

Considering all this, one can therefore argue that the data as shown in the IEA and EDP-Asia database should preferably be used for those activities for which "reliable[3]" data are required such as for instance policy initiatives in the field of forestry and energy, global warming issues, energy forecasting, etc. Unfortunately both the IEA and the EDP-Asia database lack data for the "Asia Other" and "Pacific" countries.

In order to determine the "best" estimate for woodfuel use in the Asia-Pacific region it is for obvious reasons preferable to use only one database system. One reason to do so, and probably the most important, is the fact that data within a single database system can be

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[1] It is expected that the UN database has more records than the 10 now indicated for most of the countries. However, these could not be accessed at present. The UN Energy Statistics Yearbook does give data on fuelwood, charcoal and bagasse. However, superficial calculations show some discrepancies (totals do not add up to the amount of biomass shown). Further work will be needed to reach the stage where the biomass can be sub-divided into fuelwood, charcoal and bagasse.

[2] Disaggregated data with regard to end-users are available for quite a few countries at EDP-Asia. However, these have not yet been entered into the database system due to a lack of time and manpower at EDP-Asia.

[3] It should be noted, that even though the IEA and EDP-Asia data appear to be more accurate, these data are also often based on some form of estimate, be it limited/periodical surveys, limited area samples, etc. and one can therefor also question their true accuracy.

assumed to have been treated in the same manner both in terms of definitions and in conversion factors from original units to energy units[1].

Unfortunately, given the large discrepancies between the "numbers" and the incompleteness of most databases, a single database system for the whole Asia-Pacific region is not feasible at the moment. The decision was made therefore to use a mixture of data from different database systems.

For 10 out of the 16 RWEDP countries the data contained in the EDP-Asia database were used while the IEA data were for the three OECD countries. These 13 countries are BGD, CMB, CPR, INS, MDV, BUR, NEP, PAK, THA, VIE and AUS, JPN and NZE (see the bibliography for the sources used). The reason for choosing the EDP-Asia and IEA database for these countries instead of the FAO/UN database systems is that for these countries data is available either in published form or directly made available by the government department dealing with energy or by the national statistical office. These are considered more reliable than the FAO data as the latter often makes use of estimates. This is evident from Figures A.1-A.4 which show that per capita fuelwood consumption in many countries has not changed over the last 15 years - a highly unlikely occurrence.

However, for those countries where the IEA and EDP-Asia database is far from complete (e.g. none or only one or two records) which is the case for countries covered under Asia-Other and the Pacific, the data contained in the FAO/UN database system have been used. For the same reason FAO/UN data have been used for the other RWEDP countries e.g. Bhutan, India, Lao PDR, Malaysia, the Philippines and Sri Lanka. The IEA database has been used for the OECD countries as EDP-Asia makes use of their data as they do not have information on those countries.

Table 3 provides an overview of these "best" estimates for the Asia-Pacific countries both for woodfuels as well as for biomass energy. Average annual changes have been calculated for the last 3-4 years for which data were available. Analysing the average annual increase over this period shows that increases have in general been moderate with a few exceptions, notably in Thailand as well as in Maldives, Fiji and Australia (biomass energy only).

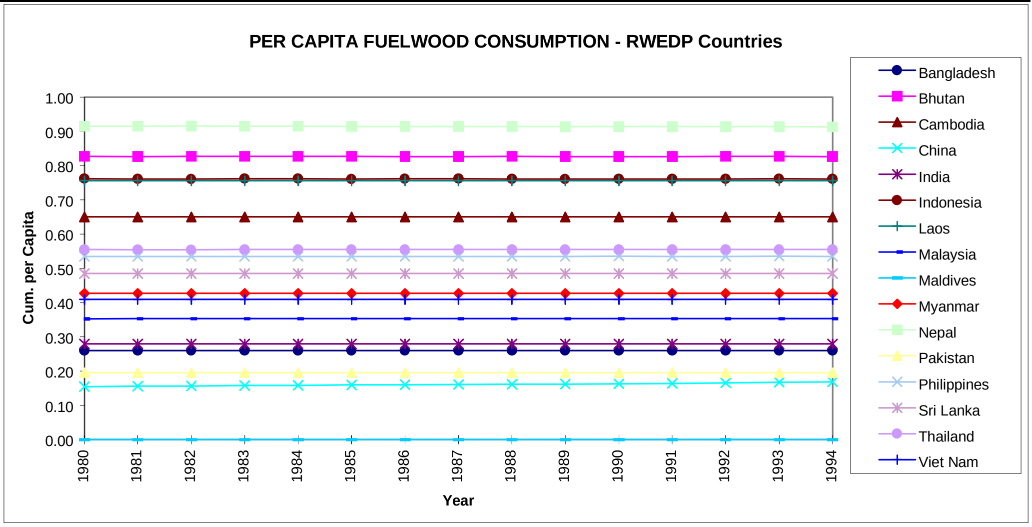
[1] An exception to this is the EDP-Asia database which often makes use of data supplied by the countries themselves. These data are in most cases already converted from original units (tons, cubic meters, etc.) to energy units by the countries.

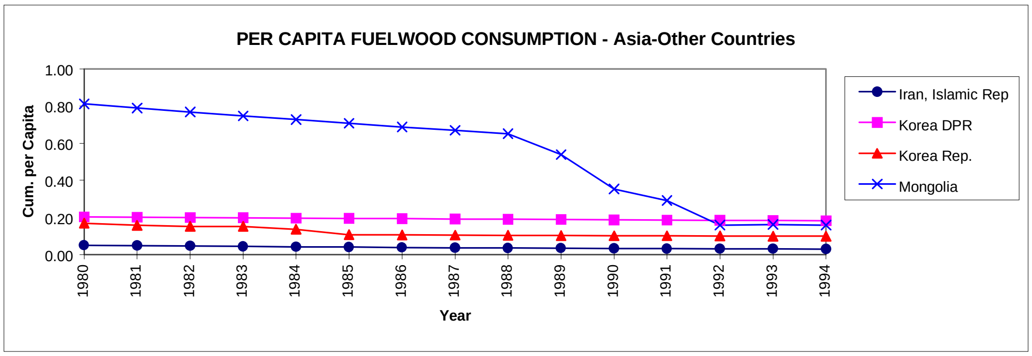
Box A2

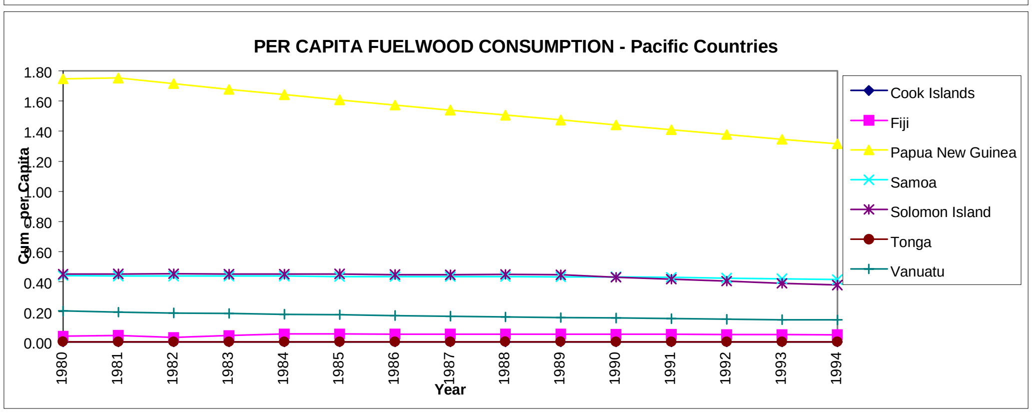
Database Systems on Energy Including Biomass in Europe versus Asia and the Pacific

A cursory review of available database systems in Europe, as presented in the "Wood Energy Today for Tomorrow" study (commissioned by FAO but not yet published) in comparison to systems for Asia and the Pacific as described in this paper, indicate that the overall situation is not much different. This appears not only to be true with regard to the amount of data available, the level of disaggregation but also with regard to "reliability". A main difference, however, is that in comparison to Asia and the Pacific, in Europe the data collection efforts appear to be more institutionalised. The result is that in Asia and the Pacific it is more time consuming to collect, compile and analyse the information. For that reason, even though disaggregated information is available for most countries in the Asia and Pacific region, the information can not yet be presented in a manner suitable for decision makers both at the national as well as international level.

Figures 1 to 4 showing the FAO data on per capita fuelwood consumption in Asia-Pacific







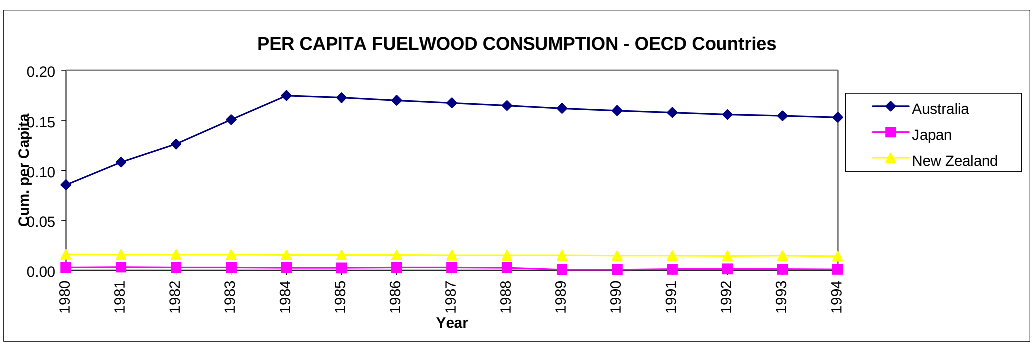


Table 3. - Best estimate with regard to woodfuel and biomass energy use in the Asia-Pacific region

WOODFUEL AND BIOMASS/RENEWABLE ENERGY CONSUMPTION IN PJ												
		Best Estimate Woodfuels				Annual change in % Woodfuels	Biomass / Combustible renewables				Annual change in % Biomass	Source - Remarks
		1992	1993	1994	1995		1992	1993	1994	1995		
	ASIA-RWEDP											
1	Bangladesh	115.0			149.0	5.32	504.0			568.0	2.42	EDP-Asia 1990 data used for 1992
2	Bhutan	12.7	12.8	12.9	13.2	1.46						FAO / UN
3	Cambodia			80.7	78.0	-3.35			87.8	83.0	-5.47	EDP-Asia
4	China	3,281.0		3,290.0		0.14	7,337.5	7,360.8	7,389.7		0.36	EDP-Asia
5	India	2,507.2	2,555.3	2,603.4	2,676.7	2.20	2,881.5	2,876.7	2,929.1		0.82	FAO / UN
6	Indonesia	787.3	797.0	817.9		1.92	787.3	797.0	817.9		1.92	EDP-Asia
7	Laos	40.0	41.1	42.4		2.97						FAO / UN
8	Malaysia	88.6	90.7	92.9	95.8	2.64	91.1	93.3	95.5		2.39	FAO / UN
9	Maldives	1.1		1.2		7.20	1.1		1.2		7.20	EDP-Asia
10	Myanmar	343.8	345.0			0.35	343.8	345.0			0.35	EDP-Asia
11	Nepal	180.6	183.9	192.0	196.0	2.77	240.4	246.2	256.1	262.0	2.91	EDP-Asia
12	Pakistan			520.8				911.0	918.2		0.80	EDP-Asia
13	Philippines	331.8	339.0	346.1	356.6	2.43	387.3					FAO / UN
14	Sri Lanka	83.2	84.2	85.3	87.1	1.52	89.4	92.2	95.0		3.06	FAO / UN
15	Thailand	588.8	647.0	691.7	703.0	6.08	693.9	755.7	825.9	870.0	7.82	EDP-Asia
16	Vietnam	423.0				1.21	815.8					EDP-Asia (increase based on 1990-1992)
	ASIA-OTHER											
17	Iran, Islamic Rep	24.4	24.5	24.7	25.0	0.85					---	FAO / UN
18	Korea DPR	40.5	40.9	41.4	42.2	1.41					---	FAO / UN
19	Korea Rep.	43.4	43.4	43.4	43.8	0.30	43.9	43.9	43.9		0.00	FAO / UN
20	Mongolia	3.5	3.6	3.6	3.7	1.67					---	FAO / UN
	PACIFIC											
21	Cook Islands										---	FAO / UN
22	Fiji	0.4	0.4	0.4	0.4	0.30	11.7	11.7	14.0		9.41	FAO / UN
23	Papua New Guinea	53.5	53.5	53.5	54.0	0.30	59.7	59.7	59.8		0.10	FAO / UN
24	Samoa	0.7	0.7	0.7	0.7	0.30					---	FAO / UN
25	Solomon Island	1.3	1.3	1.3	1.3	0.30	3.2				---	FAO / UN
26	Tonga										---	FAO / UN
27	Vanuatu	0.2	0.2	0.2	0.2	0.30					---	FAO / UN
	OECD Members											
28	Australia	90.4	92.9	93.4		1.69	164.5	181.7	188.8		7.13	IEA / EDP-Asia
29	Japan		153.5	150.5		-1.95		184.6	181.3		-1.81	IEA
30	New Zealand	26.1	27.5	27.5		2.65	41.0	42.7	42.7		2.02	IEA / EDP-Asia

The large increases in biomass energy consumption as shown in table 3 in the Maldives as well as in Fiji are probably caused by the fact that no real time series data are available (Maldives) and or in the way estimates were made (Fiji). The reason for the sharp increases for Thailand and Australia can probably be traced back to the fact that in both countries efforts are being made to promote the use of renewable energy including biomass. Another factor which may play a role in the sharp increase, particularly in biomass energy for these countries as well as for Fiji, is increased sugar production resulting in increases in bagasse use as a source of fuel. However, the same argument should then also be valid for other sugar producing countries. Unfortunately, sufficient information is not available to substantiate this assumption.

Comparing the increases in woodfuel/biomass use with those in the conventional sector (shown in table 4) it is clear that increases in the conventional energy sector are generally considerably greater than those in the wood/biomass energy sector

A1.4 Outlook for the Near Future

The demand for and supply of woodfuels and other sources of biomass energy are influenced by many factors, both at the macro level (at country and/or regional level) as well as the micro level (mainly at the end-use level which in many cases will be households). Most of these factors are to a greater or lesser extent inter-related such as for instance economic performance at the macro level may generally be expected to have some effect on income at the micro level, etc.

Some of the factors at the macro level are:

- Economic performance of the country or region concerned
- Population growth and spatial distribution (urban-rural)
- Spatial distribution of biomass energy sources and infrastructure
- Advances in technology and end-use devices
- Environmental aspects

The most important factors at the micro level are:

- Access to energy sources both with regard to ownership as well as availability (security of supply, scarcity, etc.)
- Household income
- Location (urban-rural)
- Price of energy sources
- Price and availability of conversion devices like stoves

While all these factors play a role, it is not known to what extent each of the individual factors exerts an influence on energy use itself as well as on the choice of fuel. But it is well known that with improvements in the economy (expressed as increases in per capita GNP), changes in energy use will take place (often increases in energy use and a shift from traditional sources of energy to conventional sources of energy). This latter shift is shown in figure A.5 which provides an overview of biomass energy use in relation to per capita GNP.

Table 4 - INCREASES IN PRIMARY COMMERCIAL ENERGY CONSUMPTION IN % IN THE ASIA-PACIFIC REGION

Primary Commercial Energy - Average annual increase in % and for the period 1980-1989, 1990-1994 and 1980-1994																	Source: Calculated from IEA /WRI		
		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1980/1989	1990/1994	1980/1994
	ASIA-RWEDP																		
1	Bangladesh		6.41	12.71	-3.26	9.51	10.92	11.36	10.20	15.43	7.84	5.62	-6.89	7.90	10.44	6.77	8.89	4.33	7.34
2	Bhutan		29.11	21.82	-10.41	69.55	26.32	-5.65	73.70	18.52	-27.28	42.27	0.00	0.00	0.00		17.48	0.00	14.87
3	Cambodia		5.48	11.87	7.59	10.74	1.44	3.72	0.69	3.50	0.00	9.61	0.00	0.00	0.00		4.93	0.00	4.12
4	China		-1.44	3.94	5.17	8.22	7.33	5.99	6.54	6.30	4.04	1.58	3.81	2.69	7.41	5.36	5.09	4.80	4.75
5	India		10.91	3.27	6.57	3.94	9.13	8.27	6.73	8.27	6.71	5.98	5.10	5.98	3.38	6.97	7.07	5.35	6.50
6	Indonesia		5.64	4.39	1.26	6.88	16.31	17.05	0.69	5.57	11.78	11.70	13.91	5.82	1.66	1.90	7.58	5.71	7.33
7	Laos		7.09	6.83	1.57	-6.58	-2.01	1.49	0.72	-3.39	18.13	-0.02	0.00	25.00	0.00		2.43	7.64	3.43
8	Malaysia		2.63	1.33	17.98	4.02	25.27	8.48	0.61	6.92	14.75	7.31	18.88	7.88	13.58	4.87	8.83	11.17	9.38
9	Maldives		7.22	6.62	6.21	11.78	10.46	23.91	0.00	7.71	0.00	-16.51	0.00	0.00	0.00		8.01	0.00	4.03
10	Myanmar		0.00	3.23	-1.56	11.11	8.10	9.69	-23.29	-4.19	1.64	-4.84	-0.56	-0.57	10.29	12.95	0.00	5.35	1.14
11	Nepal		-5.88	6.25	5.88	33.33	0.00	4.17	20.00	10.00	-6.06	-16.13	38.46	22.22	4.55	26.09	6.90	22.21	9.16
12	Pakistan		10.83	9.61	7.05	3.90	7.63	5.65	15.92	6.38	7.93	5.89	3.15	5.71	10.03	8.04	8.27	6.70	7.65
13	Philippines		-0.15	7.35	4.33	-3.55	-1.67	-0.92	3.99	7.53	11.40	3.77	0.44	11.14	3.46	1.15	3.04	3.96	3.35
14	Sri Lanka		0.71	11.97	0.00	-5.66	-6.67	3.57	6.90	-1.29	-1.96	4.00	5.13	0.00	27.44	0.00	0.69	7.59	2.85
15	Thailand		-1.49	1.18	10.21	10.92	5.70	2.70	16.64	12.82	17.92	23.82	8.46	9.75	9.00	11.36	8.31	9.64	9.74
16	Viet Nam		-0.75	7.77	6.98	-0.22	3.92	9.64	11.09	-1.72	-9.28	12.16	-5.85	10.97	10.38	8.51	2.86	5.76	4.32
	ASIA-OTHER																		
17	Iran, Islamic Rep		-5.16	-1.92	21.45	19.30	3.37	4.98	4.51	6.81	10.08	1.04	10.44	9.45	11.87	-1.32	6.73	7.48	6.53
18	Korea DPR		0.74	2.89	7.30	1.08	4.26	2.12	0.24	0.78	1.93	-4.98	-6.52	-8.59	-7.63	-7.45	2.35	-7.55	-1.11
19	Korea Rep.		4.01	-2.18	8.94	8.91	7.26	10.65	10.29	13.34	7.31	13.77	12.18	11.89	9.08	6.89	7.53	9.99	8.66
20	Mongolia		-1.68	2.39	4.39	-12.38	41.85	5.76	8.51	9.19	-8.68	-1.76	-2.61	-4.46	-1.87		4.57	-2.96	2.28
	PACIFIC																		
21	Cook Islands																		
22	Fiji		50.67	-24.08	-10.73	-10.09	0.26	5.90	-16.43	16.80	-5.59	47.06	-16.67	10.00	0.00		-1.19	-2.83	1.48
23	Papua New Guinea		5.41	0.46	4.20	-6.84	13.63	-2.54	12.40	-5.43	2.22	0.97	0.00	0.00	0.00		2.39	0.00	1.72
24	Samoa		6.31	9.95	0.00	0.88	0.22	0.65	-0.43	0.00	5.59						2.51		
25	Solomon Island		33.33	-9.11	14.86	2.31	4.45	1.95	5.96	-5.55	3.97	-10.21	0.00	0.00	0.00		5.20	0.00	2.72
26	Tonga		15.44	-6.58	7.04	0.00	0.00	-0.33	13.66	35.53	4.27	-3.33	0.00	0.00	0.00		7.06	0.00	4.57
27	Vanuatu		-15.19	0.00	5.84	0.00	10.71	14.95	-21.82	33.43	-12.17	11.31	0.00	0.00	0.00		0.51	0.00	1.18
	OECD Members																		
28	Australia		0.33	4.49	-4.26	3.46	0.97	1.67	4.90	1.77	6.97	2.45	-0.89	1.80	4.88	2.97	2.21	2.17	2.22
29	Japan		-2.63	-1.88	0.99	7.90	0.19	1.18	0.66	7.80	3.38	5.26	2.39	1.80	0.96	4.91	1.89	2.50	2.30
30	New Zealand		-2.54	7.58	3.52	6.70	7.48	0.74	3.13	4.73	8.35	2.28	1.54	4.70	-0.14	1.81	4.36	1.96	3.52
	Total Asia-RWEDP	0	1.22	4.03	5.49	6.95	8.09	6.81	6.47	6.74	5.55	3.79	4.88	4.12	6.58	5.67	5.69	5.30	5.44
	Total Asia-Others	0	-0.08	-0.67	12.52	10.37	5.02	6.38	5.73	8.07	7.15	5.24	8.12	7.74	7.85	2.10	5.95	6.05	5.92
	Total Pacific	0	16.48	-6.98	0.93	-6.61	9.61	-0.26	5.11	-0.44	0.69	4.79	-4.08	2.13	0.00		1.82	-0.68	1.46
	Total OECD Members	0	-2.16	-0.65	0.15	7.15	0.47	1.25	1.40	6.74	4.07	4.73	1.85	1.87	1.53	4.52	2.00	2.44	2.32
	Total Asia-Pacific	0	-0.18	1.84	4.24	7.38	5.14	4.93	4.78	6.89	5.27	4.24	4.32	3.87	5.26	4.90	4.45	4.52	4.45

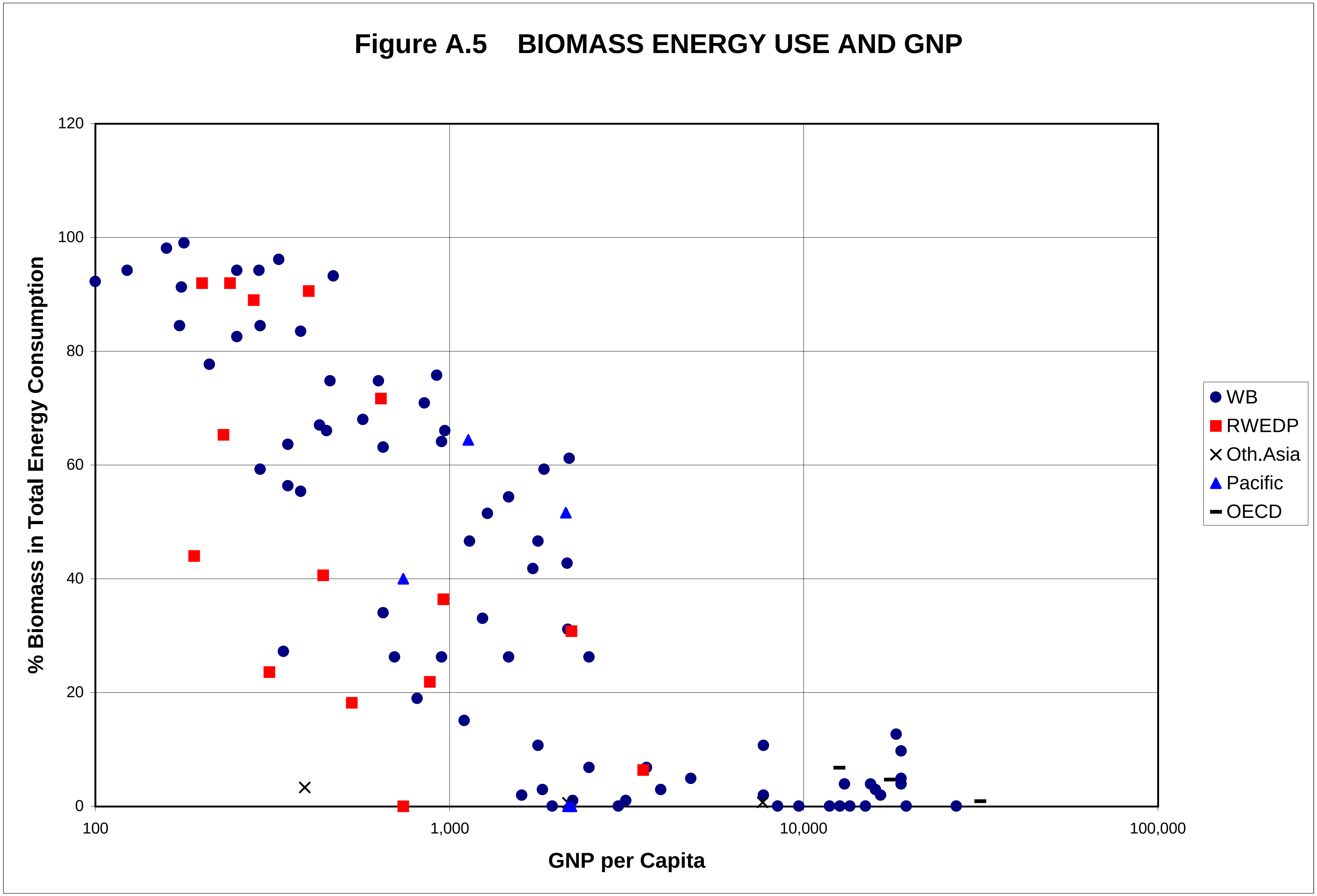


Figure A.5 BIOMASS ENERGY USE AND GNP
% Biomass in Total Energy Consumption
GNP per Capita
120
100
80
60
40
20
0
100
1,000
10,000
100,000
WB
RWEDP
Oth.Asia
Pacific
OECD

It is clear from this figure that there exists a tendency for biomass energy use to decline as GNP increases exists but no direct relationship between incremental changes in the two variables can be deducted from the data. Households with increased family incomes often switch from biomass fuels to others (stepping up the fuel ladder) like electricity and gas. However, if these are not available or if the supply is not reliable, they may decide not to upgrade their fuel. Likewise, where woodfuel resources are scarce, people may downgrade to lower quality fuels. This illustrates that fuel switching is an extremely complex system and predictions for the future are difficult to make.

In order to explore the possibility of providing an alternative to the usual simple extrapolation of trends used for projections, two computer modelling exercises were conducted by RWEDP staff. One exercise was based on the data contained in a study carried out on behalf of FAO (Provisional Outlook for Global Forest Products Consumption, Production and Trade to 2010) which has a brief section on woodfuels. The other is based on the "best" estimates for woodfuel use presented in this paper. The results of both exercises are shown in table 5.

For the first exercise using the FAO data (shown in table III-2 page 109 of the FAO publication), the average annual growth rates were calculated for the period 1994-2000 and 2000-2010. Many factors such as economic growth rates, forest resources, population, etc. were taken into account. However, as was indicated earlier in this paper, the validity of the base year (woodfuel use in 1994) can be questioned as in many instances these data are based on estimates made before 1961 and per capita woodfuel use has been assumed to have remained constant since 1961).

The second exercise is based on the "best" estimates as arrived at in this paper. Growth rates for the period 1994-2000 were assumed to remain the same as were calculated for the period 1992-1994. For the period 2000-2010 the growth rates were reduced by assuming that the reduction in the growth rates as shown in exercise 1 would also be valid for the second exercise. The justification for this assumption of reduced growth in the consumption of fuelwood as a source of energy is that the basic underlying assumptions on economic growth rates, forest resources and population growth are sound.

Table 5 shows that the difference between the results of the exercise based on FAO data and the exercise based on "best" estimates is about 170 million cubic meter in 1994 (about 850 million cum. versus 1,020 million cum.). The difference would rise to about 260 million cum. in the year 2010 (1,020 million cum. versus 1,280 million cum.). Such calculations are interesting as they show the differences which can occur using different assumptions. At the same time it should be noted that these projections are based on assumptions and one has therefore to be very careful in using such figures. This is also evident from a cursory comparison of the projected growth rates used in this paper with those available from two countries. The projected growth rate for fuelwood use for the Philippines for the period 1996-2010 is about 2.22% (DOE, 1996). This is more or less in line with those used for the RWEDP/EDP-Asia projection (2.43% for 1994-2000 and 2.22% for 2000-2010). However, the projection method used in Nepal (WECS, 1996a) shows a considerably lower growth rate (but still higher than the FAO projection) of 1.35% for the period 1995-2010 versus 2.77% and 2.14% respectively for the period 1994-2000 and 2000-2010 as used for the RWEDP/EDP-Asia projection.

Nevertheless, the main message which can be derived from this discussion on supply-demand projections is that woodfuel use is here to stay and is growing even though its share in overall energy consumption will decline.

Very superficial calculations, using business-as-usual projections made by UN-ESCAP for conventional energy use (Energy Supply and Demand Trends in Asia and the Pacific) show that in 1994 woodfuels accounted for about 8.2% to 9.8% of total energy consumption (total energy consumption here is taken to mean conventional fuels plus woodfuels and excludes other biomass energy). In the year 2010 the share of woodfuels will have dropped to about 4.6 to 5.7% depending on which scenario for woodfuel projection is used.

Table 5. Sample projections for woodfuel use for the period 1994-2010

	FAO - Global Forest Products Outlook to 2010 Projected Fuelwood Consumption					RWEDP - EDP-Asia Projected Woodfuel Consumption 1994 - 2010					
Country groupings	**Fuelwood consumption in '000 Cum. per year**			**Average annual Growth rate %**		**Average annual growthrate**		**Projected annual grwothrate**	**Fuelwood consumption in '000 Cum. per year**		
	1994	**2000**	**2010**	**1994/2000**	**2000/2010**	**1980/1994**	**1992/1994**	**2000/2010**	1994	2000	2010
RWEDP											
Bangladesh	30,620	32,356	35,012	0.92	0.79	4.18	5.32	4.57	14,455	19,728	30,829
Bhutan							1.46		1,260	1,375	1,375
Cambodia	6,454	7,047	7,790	1.48	1.01	-3.35	-3.35	-2.29	8,269	6,740	5,348
China	204,094	227,209	255,839	1.80	1.19	-2.64	0.14	0.09	337,110	339,951	343,115
India	256,485	275,270	302,387	1.18	0.94	2.07	2.20	1.75	266,788	303,999	361,705
Indonesia	147,033	163,319	180,146	1.77	0.99	2.55	1.92	1.07	83,806	93,936	104,503
Laos	3,583	3,878	4,278	1.33	0.99	2.75	2.97	2.21	4,342	5,176	6,440
Maldives							7.20	5.40	123	187	316
Malaysia	6,845	7,585	8,523	1.72	1.17	2.59	2.54	1.73	9,519	11,065	13,131
Myanmar	19,331	21,050	23,227	1.43	0.99	0.99	0.35	0.24	35,474	36,226	37,113
Nepal	19,500	20,819	22,647	1.10	0.85	2.23	2.77	2.14	19,673	23,178	28,631
Pakistan	26,700	28,413	31,076	1.04	0.90		1.04	0.90	53,364	56,781	62,096
Philippines	35,170	37,245	40,635	0.96	0.87	2.26	2.43	2.22	35,463	40,958	50,993
Sri Lanka	8,779	9,442	10,339	1.22	0.91	1.29	1.52	1.14	8,740	9,568	10,712
Thailand	32,318	35,505	39,735	1.58	1.13	7.51	6.08	4.36	70,875	100,994	154,723
Vietnam	29,761	32,968	37,030	1.72	1.17	1.21	1.21	0.82	45,182	48,563	52,708
Oth.Asia											
Iran, Islamic Rep	1,997	2,103	2,253	0.87	0.69	0.92	0.85	0.68	2,531	2,663	2,849
Korea DPR	4,276	4,497	4,854	0.84	0.77	0.93	1.41	1.28	4,242	4,614	5,241
Korea Rep.	4,678	5,176	5,801	1.70	1.15	-2.69	0.3	0.20	4,447	4,528	4,620
Mongolia	376	395	427	0.82	0.78	-8.07	1.67	1.58	369	407	477
Pacific											
Fiji	37	38	41	0.45	0.76		0.3	0.51	41	42	44
Papua New Guinea	5,533	5,714	6,008	0.54	0.50	0.27	0.3	0.28	5,482	5,581	5,740
Samoa	70	74	80	0.93	0.78		0.3	0.25	72	73	75
Solomon Islands	138	139	144	0.12	0.35		0.3	0.88	133	136	148
Vanuatu	24	25	26	0.68	0.39		0.3	0.17	20	21	21
OECD											
Australia	2,696	2,170	1,629	-3.55	-2.83	2.36	1.69	1.35	9,570	10,583	12,096
Japan	431	361	270	-2.91	-2.86	-1.95	-1.95	-1.92	0	0	0
New Zealand	50	38	28	-4.47	-3.01	2.23	2.65	1.78	2,818	3,297	3,934
Total '000 Cum. for region	**846,979**	**922,836**	**1,020,225**	**1.44**	**1.01**		**1.66**	**1.40**	**1,024,170**	**1,130,369**	**1,298,981**

Data in grey are based upon FAO data (production in the past)

A1.5 Conclusions

While searching for and analysing available data on wood/biomass energy it has become clear that a considerable amount of data is available from various sources. However, at the same time it was also found that quite a few of these sources of data are making use of data provided by other organizations. An example of this is the United Nations (UN) as well as the World Resources Institute (WRI) who both make use of data on fuelwood and charcoal provided by FAO. While FAO clearly indicates which data are based on estimates, the same is not true for both the UN and WRI. Likewise, IEA/OECD, although mentioning that their data sources for the Non-OECD countries may be suspect still publish it. Others, e.g. EDP-Asia, make use of such data and may even use it to build scenarios, etc.

One should therefore be very careful to check the “status” of the data provided by the various organizations maintaining and publishing a database on woodfuel/biomass energy use.

Another main conclusion is that definitions used by the various organizations are in many cases not comparable and again care should be taken to check what is meant when terms such as woodfuels, fuelwood, residues, etc. are used. There is a clear need to come to some form of a unified approach with regard to definitions and conversion factors used for wood and biomass energy by the various organizations involved in the collection and analysis of such data.

The manner is which estimates are made also leaves something to be desired. FAO, in those cases where the countries do not provide information on woodfuel use, makes use of estimates based, in most cases, on per capita consumption figures. These per capita consumption figures have often not been changed since the first estimate was made (often circa 1961) and this practice no doubt may lead to large discrepancies over time.

All databases, which present information on woodfuels, etc. do so without making any distinction with regard to the source (e.g. forest land, non-forest land, recycled wood, etc.). Besides, little information is provided with regard to end-use. The UN, IEA and EDP-Asia database provides some limited information on sectoral end-use. It would be relevant to make some kind of distinction between location of the source as well as the end-user e.g. by urban/rural as such information will be relevant for policy related matters.

All this indicates that there is a need to have more direct contacts between the different database owners with a view to improve the consistency and comparability of the different data sources in order that the users of these database systems are better served.

BIBLIOGRAPHY

The following sources were used by the EDP-Asia database

Bangladesh	Government of Bangladesh,1987 Government of Bangladesh, 1996 (1990 data) Habib, A.,1994. (estimates for 1995)
Bhutan	Ministry of Agriculture of Bhutan, 1991
Cambodia	MIME, 1996
China	LBL, 1996 (for 1987, 1990 and 1992 data) IEA, 1996c (for 1993 and 1994 data)
India	N.A.
Indonesia	Biro Statistik, 1994
Lao PDR	REDP, 1989a
Malaysia	N.A.
Maldives	UN, 1995
Myanmar	Personal Communications, 1996
Nepal	WECS, 1996a WECS, 1996b
Pakistan	AIT, 1995
Philippines	IEA, 1996c
Sri Lanka	CEB, 1995
Thailand	DEDP, 1992, 1993, 1994, 1995, 1997
Vietnam	World Bank, 1994 World Bank/ESMAP, 1994 (for 1992 biomass energy in the domestic sector) Institute of Energy, 1995 (for 1990 and 1992 conventional energy data)
Iran	N.A.
Democratic Republic of Korea	N.A.
Republic of Korea	IEA, 1996c (for biomass data)
Mongolia	N.A.

Cook Islands	N.A.
Fiji	World Bank/ESMAP, 1983
Papua New Guinea	World Bank/ESMAP, 1982 (for 1980 data) PEC, 1992 (for 1990 data)
Western Samoa	World Bank/ESMAP, 1983
Solomon Islands	World Bank/ESMAP, 1983
Tonga	World Bank/ESMAP, 1985
Vanuatu	World Bank/ESMAP, 1985
Australia	IEA, 1996a and b
Japan	IEA, 1996a and b
New Zealand	IEA, 1996a and b

WOODFUELS (FW +Charcoal as FW) **PRODUCTION IN PJ = (TPES excl. Exp./Imp.)** **Source: Calculated from FAOSTAT-PC**

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh	222	227	233	238	243	248	253	257	262	267	272	277	283	290	296	0	0	0	0
2	Bhutan	10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	0	0	0	0
3	Cambodia	41	41	43	44	46	48	49	51	52	54	56	57	59	61	63	0	0	0	0
4	China	1,496	1,525	1,556	1,587	1,619	1,651	1,684	1,718	1,752	1,787	1,823	1,859	1,897	1,935	1,974	0	0	0	0
5	India	1,953	1,995	2,039	2,085	2,131	2,178	2,224	2,271	2,317	2,364	2,411	2,459	2,507	2,555	2,603	0	0	0	0
6	Indonesia	1,117	1,141	1,165	1,190	1,215	1,238	1,262	1,286	1,308	1,330	1,353	1,375	1,396	1,419	1,440	0	0	0	0
7	Laos	29	29	30	30	31	32	33	34	35	36	38	39	40	41	42	0	0	0	0
8	Malaysia	65	67	68	70	72	74	76	78	80	82	84	86	89	91	93	0	0	0	0
9	Maldives																0	0	0	0
10	Myanmar	140	142	145	149	152	155	158	162	165	169	173	176	181	191	194	0	0	0	0
11	Nepal	133	136	140	144	148	152	155	159	163	167	172	176	181	186	190	0	0	0	0
12	Pakistan	161	167	173	180	187	194	201	208	216	229	234	240	248	257	265	0	0	0	0
13	Philippines	253	259	264	270	278	283	290	296	302	308	315	322	332	339	346	0	0	0	0
14	Sri Lanka	71	72	74	75	76	76	77	78	79	80	81	82	83	84	85	0	0	0	0
15	Thailand	281	286	291	297	302	307	313	318	324	329	334	338	342	346	349	0	0	0	0
16	Viet Nam	212	217	222	227	232	237	242	247	252	258	264	270	276	282	288	0	0	0	0
	ASIA-OTHER																			
17	Iran, Islamic Rep	22	23	23	23	23	23	23	24	24	24	24	24	24	24	25	0	0	0	0
18	Korea DPR	36	36	37	37	37	38	38	38	39	39	40	40	40	41	41	0	0	0	0
19	Korea Rep.	63	60	59	60	54	43	43	43	43	43	43	43	43	43	43	0	0	0	0
20	Mongolia	13	13	13	13	13	13	13	13	13	11	7	6	3	4	4	0	0	0	0
	PACIFIC																			
21	Cook Islands																0	0	0	0
22	Fiji	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Papua New Guinea	52	54	54	54	54	54	54	54	54	54	54	54	54	54	54	0	0	0	0
24	Samoa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
25	Solomon Island	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
26	Tonga																0	0	0	0
27	Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	OECD Members																			
28	Australia	14	17	20	24	28	28	28	28	28	28	28	28	28	28	28	0	0	0	0
29	Japan	6	6	6	6	5	5	6	6	6	3	3	4	4	3	3	0	0	0	0
30	New Zealand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Asia-RWEDP	6,183	6,316	6,454	6,597	6,741	6,882	7,029	7,174	7,320	7,473	7,619	7,770	7,928	8,089	8,243	0	0	0	0
	Total Asia-Others	112	109	108	110	104	94	94	95	95	94	90	90	87	88	88	0	0	0	0
	Total Pacific	54	56	56	56	56	56	56	56	56	56	56	56	56	56	56	0	0	0	0
	Total OECD Members	6	6	6	6	6	6	6	6	6	4	4	4	4	4	4	0	0	0	0
	Total Asia-Pacific	6,355	6,488	6,624	6,768	6,907	7,038	7,185	7,331	7,477	7,627	7,770	7,920	8,075	8,237	8,392	0	0	0	0

Charcoal converted to Fuelwood in a ratio of 6 cum. fuelwood per 1 ton charcoal

	PRIMARY FUELWOOD CONSUMPTION IN PJ															Source:IEA, etc.				
		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh																			
2	Bhutan																			
3	Cambodia																			
4	China																			
5	India																			
6	Indonesia																			
7	Laos																			
8	Malaysia																			
9	Maldives																			
10	Myanmar																			
11	Nepal																			
12	Pakistan																			
13	Philippines																			
14	Sri Lanka																			
15	Thailand																			
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.																			
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji																			
23	Papua New Guinea																			
24	Samoa																			
25	Solomon Island																			
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia								79	81	84	86	89	90	93	93				
29	Japan														0	0				
30	New Zealand								24	25	27	25	27	26	28	28				
	Total Asia-RWEDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Asia-Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Pacific	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total OECD Members	0.00	0.00	0.00	0.00	0.00	0.00	0.00	102.51	105.23	111.00	111.22	115.97	116.45	120.42	120.93	0.00	0.00	0.00	0.00
	Total Asia-Pacific	0.00	0.00	0.00	0.00	0.00	0.00	0.00	102.51	105.23	111.00	111.22	115.97	116.45	120.42	120.93	0.00	0.00	0.00	0.00

Wood does not include black liquor

TPES - FUELWOOD AND CHARCOAL (PJ)

Source: EDP-Asia Database

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh		84									115					149			
2	Bhutan										15									
3	Cambodia															81	78			
4	China								3,967			3,907		3,281		3,290				
5	India																			
6	Indonesia							669	686	701	710	734	758	787	797	818				
7	Laos											34								
8	Malaysia																			
9	Maldives													1		1				
10	Myanmar							322	326	331	334	341	346	344	345					
11	Nepal		144	149	152	155	159	162	164	167	170	172	176	181	184	192	196			
12	Pakistan															521				
13	Philippines																			
14	Sri Lanka																			
15	Thailand					317	360	402	435	463	497	530	548	589	647	692	703			
16	Viet Nam											413		423						
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.																			
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji			3																
23	Papua New Guinea											23								
24	Samoa				1															
25	Solomon Island		2																	
26	Tonga																			
27	Vanuatu				1															
	OECD Members																			
28	Australia								79	81	84	86	89	90	93	93				
29	Japan																			
30	New Zealand								24	25	27	25	27	26	28	28				

For OECD Countries "Black Liquor" is not included in woodfuels, for other countries this can not be ascertained

Numbers in *Italic* are provisional/estimated/un-official

Data are non-standardized e.g. conversion factors from physical to energy units are those as used by the individual countries and/or original sources

TOTAL PRIMARY BIOMASS ENERGY REQUIREMENTS (TPES) IN PJ

Source:UN '88, '92, '94

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh						260	262	264	269	270	274	345	343	342	338				
2	Bhutan																			
3	Cambodia																			
4	China										1,918	1,959	2,018	2,095	2,123	2,121				
5	India						2,379	2,441	2,530	2,603	2,626	2,726	2,814	2,881	2,877	2,929				
6	Indonesia						1,286	1,319	1,342	1,324	1,405	1,435	1,449	1,469	1,495	1,515				
7	Laos																			
8	Malaysia						77	78	80	82	85	88	89	91	93	95				
9	Maldives																			
10	Myanmar												181	186	196	199				
11	Nepal						142	197	201	205	209	206	211	219	222	229				
12	Pakistan						233	233	247	267	270	275	286	304	313	326				
13	Philippines						322	327	331	347	365	367	380	387						
14	Sri Lanka						78	74	79	79	88	89	90	89	92	95				
15	Thailand						460	457	453	448	474	451	448	679	760	803				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.						85	62	55	49	43	33	44	44	44	44				
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji						3	8	7	7	8	8	12	12	12	14				
23	Papua New Guinea						57	59	59	60	60	56	60	60	60	60				
24	Samoa																			
25	Solomon Island						4	4	4	4	3	3	3	3						
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia																			
29	Japan																			
30	New Zealand																			
	Total Asia-RWEDP	0	0	0	0	0	5,237	5,389	5,527	5,624	7,709	7,870	8,311	8,743	8,513	8,651	0	0	0	0
	Total Asia-Others	0	0	0	0	0	85	62	55	49	43	33	44	44	44	44	0	0	0	0
	Total Pacific	0	0	0	0	0	64	71	70	71	71	68	75	75	71	74	0	0	0	0
	Total OECD Members	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Asia-Pacific	0	0	0	0	0	5,386	5,522	5,653	5,743	7,824	7,971	8,430	8,861	8,628	8,769	0	0	0	0

PRIMARY COMBUSTIBLE RENEWABLE ENERGY CONSUMPTION IN PJ

Source: IEA, etc.

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh																			
2	Bhutan																			
3	Cambodia																			
4	China														7,231	7,259				
5	India																			
6	Indonesia														1,111	1,111				
7	Laos																			
8	Malaysia																			
9	Maldives																			
10	Myanmar																			
11	Nepal														255	262				
12	Pakistan																			
13	Philippines														499	499				
14	Sri Lanka																			
15	Thailand														742	811				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.														31	38				
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji																			
23	Papua New Guinea																			
24	Samoa																			
25	Solomon Island																			
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia	151	160	166	165	160	165	166	161	164	174	178	177	165	182	189				
29	Japan													92	185	181				
30	New Zealand	23	24	23	22	22	24	23	24	25	28	40	42	41	43	42.71				
	Total Asia-RWEDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9,838.06	9,941.89	0.00	0.00	0.00	0.00
	Total Asia-Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.07	37.93	0.00	0.00	0.00	0.00
	Total Pacific	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total OECD Members	173.75	184.22	189.66	186.31	182.54	189.24	189.24	185.06	188.82	201.39	218.13	219.39	297.68	409.05	412.82	0.00	0.00	0.00	0.00
	Total Asia-Pacific	173.75	184.22	189.66	186.31	182.54	189.24	189.24	185.06	188.82	201.39	218.13	219.39	297.68	10,278.18	10,392.64	0.00	0.00	0.00	0.00

Combustible renewables includes woodfuels, vegetal waste, black liquor, municipal solid waste, industrial and other waste, landfill gas,sludge, bio-fuels, etc.

IEA General conversion factor used for conversion from MTOE to PJ (41.868)

TPES - BIOMASS ENERGY (PJ) — *Source: EDP-Asia Database*

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh		479									504					568			
2	Bhutan										15									
3	Cambodia															88	83			
4	China								7,934			7,845		7,338	7,361	7,390				
5	India																			
6	Indonesia							669	686	701	710	734	758	787	797	818				
7	Laos											34								
8	Malaysia																			
9	Maldives													1		1				
10	Myanmar							322	326	331	334	341	346	344	345					
11	Nepal		188	193	197	201	205	209	213	218	223	227	233	240	246	256	262			
12	Pakistan														911	918				
13	Philippines															508				
14	Sri Lanka										198	200		174						
15	Thailand					404	457	493	520	545	609	630	652	694	756	826	870			
16	Viet Nam											443		816						
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.															39	45			
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji			13																
23	Papua New Guinea	18										30								
24	Samoa				3															
25	Solomon Island		3																	
26	Tonga				1															
27	Vanuatu				2															
	OECD Members																			
28	Australia	151	160	166	165	160	165	166	161	164	174	178	177	165	182	189				
29	Japan													92	185	181				
30	New Zealand	23	24	23	22	22	24	23	24	25	28	40	42	41	43	43				

Data for OECD countries are "Combustible renewables and wastes" e.g. include industrial and municipal wastes as well as gaseous and liquid biomass based fuels

Numbers in *Italic* are provisional/estimated/un-official

Data are non-standardized e.g. conversion factors from physical to energy units are those as used by the individual countries and/or original sources

FAO - Share of woodfuels in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % — **Source: EDP-Asia Database**

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh	65.3	64.5	62.3	63.5	61.9	59.9	57.8	55.8	52.7	51.3	50.4	52.7	51.3	49.4	48.3				
2	Bhutan	96.8	96.0	95.2	95.8	93.2	91.7	92.3	87.6	86.0	89.6	86.1	86.2	86.3	86.5					
3	Cambodia	90.8	90.5	89.7	89.3	88.7	88.9	88.9	89.2	89.1	89.4	88.8	89.1	89.5	89.7					
4	China	8.0	8.2	8.1	7.8	7.4	7.1	6.8	6.6	6.3	6.2	6.2	6.1	6.1	5.8	5.6				
5	India	33.2	31.4	31.2	30.3	29.9	28.6	27.4	26.5	25.4	24.5	23.8	23.3	22.6	22.4	21.5				
6	Indonesia	50.7	49.9	49.3	49.6	48.4	45.1	41.7	42.0	41.1	38.9	36.6	34.0	33.1	33.1	33.0				
7	Laos	89.9	89.4	89.0	89.1	89.9	90.4	90.5	90.7	91.2	90.1	90.4	90.6	88.9	89.2					
8	Malaysia	14.0	14.0	14.1	12.5	12.4	10.4	9.9	10.1	9.7	8.8	8.4	7.4	7.0	6.4	6.2				
9	Maldives																			
10	Myanmar	64.2	64.7	64.4	65.2	63.3	62.0	60.3	66.9	68.3	68.4	70.0	70.5	71.2	70.3	68.0				
11	Nepal	94.9	95.3	95.2	95.0	93.6	93.8	93.7	92.7	92.2	92.8	94.0	92.1	90.8	90.6	88.7				
12	Pakistan	25.2	23.9	22.9	22.4	22.4	21.7	21.4	19.6	19.2	18.9	18.4	18.3	18.0	17.1	16.5				
13	Philippines	31.1	31.7	30.6	30.2	31.6	32.3	33.1	32.6	31.5	29.6	29.3	29.7	28.1	27.9	28.1				
14	Sri Lanka	54.7	54.9	52.5	53.0	54.8	56.5	55.9	54.6	55.3	56.1	55.3	54.4	54.8	49.0	49.3				
15	Thailand	35.7	36.5	36.6	34.8	32.9	32.0	31.8	28.9	26.9	24.1	20.6	19.5	18.3	17.2	15.8				
16	Viet Nam	55.8	56.5	55.2	54.1	54.7	54.3	52.5	50.4	51.4	54.3	52.0	54.1	52.0	50.1	48.6				
	ASIA-OTHER																			
17	Iran, Islamic Rep	1.4	1.5	1.5	1.2	1.1	1.0	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6				
18	Korea DPR	2.7	2.7	2.7	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.5	2.7	3.0	3.3	3.6				
19	Korea Rep.	3.5	3.2	3.2	3.0	2.5	1.9	1.7	1.6	1.4	1.3	1.1	1.0	0.9	0.8	0.8				
20	Mongolia	14.3	14.5	14.2	13.7	15.3	11.3	10.8	10.0	9.2	8.6	6.1	5.3	3.2	3.3					
	PACIFIC																			
21	Cook Islands																			
22	Fiji	2.5	1.9	1.7	2.8	4.1	4.1	3.9	4.6	4.0	4.2	2.9	3.5	3.2	3.2					
23	Papua New Guinea	66.4	65.8	65.7	64.7	66.3	63.4	64.0	61.3	62.6	62.1	61.9	61.9	61.9	61.9					
24	Samoa	32.5	31.2	29.2	29.2	29.0	29.0	28.8	28.9	28.9	27.8									
25	Solomon Island	41.1	35.3	38.3	35.7	36.0	36.0	36.1	35.5	37.7	37.5	40.0	40.0	40.0	40.0					
26	Tonga																			
27	Vanuatu	21.3	24.2	24.2	23.2	23.2	21.4	19.1	23.2	18.5	20.5	18.8	18.8	18.8	18.8					
	OECD Members																			
28	Australia	0.5	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7				
29	Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
30	New Zealand	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1				

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray
Comparison between Total and Woodfuels (Biomass not available)

IEA - Share of woodfuels in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % ***Source: EDP-Asia Database***

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh																			
2	Bhutan																			
3	Cambodia																			
4	China																			
5	India																			
6	Indonesia																			
7	Laos																			
8	Malaysia																			
9	Maldives																			
10	Myanmar																			
11	Nepal																			
12	Pakistan																			
13	Philippines																			
14	Sri Lanka																			
15	Thailand																			
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.																			
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji																			
23	Papua New Guinea																			
24	Samoa																			
25	Solomon Island																			
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia								2.6	2.6	2.5	2.5	2.7	2.6	2.6	2.5				
29	Japan														0.8	0.7				
30	New Zealand								4.9	4.8	4.9	6.7	7.1	6.6	6.8	6.7				

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray

Comparison between Total and Woodfuels

EDP-Asia - Share of woodfuels in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % — ***Source: EDP-Asia Database***

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh		13.8									14.9								
2	Bhutan										90.6									
3	Cambodia															92.0				
4	China								12.3			11.1		9.0		8.1				
5	India																			
6	Indonesia							27.5	27.9	27.2	25.3	23.9	22.1	21.8	21.8	21.9				
7	Laos											89.4								
8	Malaysia																			
9	Maldives													51.9						
10	Myanmar							75.5	80.3	81.2	81.1	82.2	82.4	82.4	81.0					
11	Nepal		74.0	74.2	74.3	73.5	73.7	73.7	72.6	71.9	72.0	72.2	70.8	69.8	69.3	68.5				
12	Pakistan															23.0				
13	Philippines																			
14	Sri Lanka																			
15	Thailand					31.0	32.5	34.5	33.5	32.5			26.8	26.5	26.7	25.8				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.																			
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji			13.0																
23	Papua New Guinea											36.8								
24	Samoa				24.2															
25	Solomon Island		39.6																	
26	Tonga																			
27	Vanuatu				36.7															
	OECD Members																			
28	Australia								2.4	2.4	2.3	2.4	2.4	2.5	2.4	2.3				
29	Japan																			
30	New Zealand								4.9	4.8	4.9	4.2	4.6	4.2	4.4	4.4				

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray
Comparison between Total and Biomass energy

UN - Share of biomass in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % — **Source: EDP-Asia Database**

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh						61.1	58.7	56.5	53.4	51.6	50.6	58.1	56.1	53.6	51.6				
2	Bhutan																			
3	Cambodia																			
4	China										6.6	6.7	6.6	6.7	6.3	6.0				
5	India						30.4	29.3	28.7	27.6	26.5	26.1	25.8	25.1	24.5	23.6				
6	Indonesia						46.1	42.8	43.1	41.4	40.2	38.0	35.2	34.3	34.3	34.2				
7	Laos																			
8	Malaysia						10.7	10.2	10.4	10.0	9.0	8.7	7.6	7.2	6.5	6.4				
9	Maldives																			
10	Myanmar												71.1	71.7	70.8	68.5				
11	Nepal						93.4	95.0	94.1	93.7	94.1	95.0	93.3	92.2	92.0	90.4				
12	Pakistan						25.0	24.0	22.5	22.8	21.6	20.9	21.1	21.2	20.1	19.5				
13	Philippines						35.2	35.8	35.1	34.5	33.3	32.6	33.2	31.3						
14	Sri Lanka						57.1	55.0	54.9	55.1	58.3	57.6	56.9	56.6	51.3	52.0				
15	Thailand						41.4	40.6	36.7	33.7	31.3	26.0	24.3	30.7	31.3	30.2				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.						3.7	2.4	2.0	1.5	1.3	0.9	1.0	0.9	0.8	0.8				
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji						27.6	47.3	48.3	44.5	50.3	41.4	54.2	51.6	51.6					
23	Papua New Guinea						64.7	66.2	63.7	65.2	64.6	63.0	64.4	64.4	64.4					
24	Samoa																			
25	Solomon Island						64.7	64.2	62.9	64.2	59.1	61.7	61.8	61.7						
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia																			
29	Japan																			
30	New Zealand																			

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray
Comparison made between Total and Biomass energy (no information on woodfuels)

IEA - Share of combustible renewable sources of energy in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % — **Source: EDP-Asia Database**

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh																			
2	Bhutan																			
3	Cambodia																			
4	China														18.7	18.0				
5	India																			
6	Indonesia														27.9	27.6				
7	Laos																			
8	Malaysia																			
9	Maldives																			
10	Myanmar																			
11	Nepal														93.0	91.5				
12	Pakistan																			
13	Philippines														36.2	36.0				
14	Sri Lanka																			
15	Thailand														30.8	30.4				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.														0.6	0.7				
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji																			
23	Papua New Guinea																			
24	Samoa																			
25	Solomon Island																			
26	Tonga																			
27	Vanuatu																			
	OECD Members																			
28	Australia	5.1	5.4	5.4	5.5	5.2	5.3	5.3	4.9	4.9	4.9	4.9	4.9	4.5	4.7	4.7				
29	Japan													0.5	1.0	0.9				
30	New Zealand	5.9	6.3	5.8	5.2	5.0	5.1	4.8	4.9	4.9	4.9	6.8	7.1	6.6	6.9	6.8				

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray
Comparison betewwn Total and Combustible Renewable Energy

EDP-Asia - Share of biomass in % of total energy consumption

SHARE OF BIOMASS/RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION IN % — **Source: EDP-Asia Database**

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	ASIA-RWEDP																			
1	Bangladesh		79.3									65.3								
2	Bhutan										91.3									
3	Cambodia																			
4	China								24.5			22.2		20.0	19.0	18.2				
5	India																			
6	Indonesia							27.5	27.9	27.2	25.3	23.9	22.1	21.8	21.8	21.9				
7	Laos											89.4								
8	Malaysia																			
9	Maldives													51.9						
10	Myanmar							75.5	80.3	81.2	81.1	82.2	82.4	82.4	81.0					
11	Nepal		96.6	96.4	96.3	95.2	95.3	95.2	94.4	94.0	94.5	95.4	93.9	92.9	92.7	91.3				
12	Pakistan														42.2	40.6				
13	Philippines															36.4				
14	Sri Lanka										75.9	75.4		71.7						
15	Thailand					39.6	41.2	42.4	40.0	38.2	37.0	32.9	31.8	31.2	31.2	30.8				
16	Viet Nam																			
	ASIA-OTHER																			
17	Iran, Islamic Rep																			
18	Korea DPR																			
19	Korea Rep.															0.7				
20	Mongolia																			
	PACIFIC																			
21	Cook Islands																			
22	Fiji			56.5																
23	Papua New Guinea	41.2										47.2								
24	Samoa				62.1															
25	Solomon Island		62.1																	
26	Tonga				63.3															
27	Vanuatu				75.8															
	OECD Members																			
28	Australia	5.1	5.4	5.4	5.5	5.2	5.3	5.3	4.9	4.9	4.9	4.9	4.9	4.5	4.7	4.7				
29	Japan													0.5	1.0	0.9				
30	New Zealand	5.9	6.3	5.8	5.2	5.0	5.1	4.8	4.9	4.9	4.9	6.8	7.1	6.6	6.9	6.8				

Data for commercial energy use are based on IEA data. Where not available, other data sources have been used (these country names are indicated in gray
Comparison between Total and Biomass energy

ANNEX 2

TABLE: CORRELATION BETWEEN FAO-PUBLISHED DATA FOR TOTAL FUELWOOD PRODUCTION AND POPULATION IN RWEDP MEMBER COUNTRIES 1964-1994

Fuelwood Production versus Population in RWEDP Countries

Source: FAO

The table shows the correlation between the fuelwood production and population as provided by FAO statistics. It shows that this correlation is 1 for all countries except China.

The correlation between fuelwood production and population is calculated by using a formula to calculate the correlation over the whole range of years for which data are available.

	Bangladesh		Bhutan		Cambodia		China		India		Indonesia		PDR Lao		Malaysia	
	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.	Prod.	Pop.
	1000 cum	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*	*1000 cum*	*1000*
1961	13,710	52,724	718	868	3,618	5,564	106,179	669,392	126,400	452,476	74,770	98,256	1,682	2,227	2,967	8,401
1962	14,050	54,053	730	883	3,705	5,698	108,181	682,357	129,287	462,780	76,360	100,345	1,720	2,277	3,062	8,671
1963	14,410	55,417	742	898	3,795	5,836	110,194	696,552	132,175	473,292	77,990	102,485	1,759	2,328	3,160	8,948
1964	14,780	56,832	755	914	3,891	5,984	113,172	712,142	135,166	484,071	79,680	104,708	1,798	2,379	3,258	9,226
1965	15,160	58,312	768	930	3,993	6,141	115,199	729,191	138,259	495,157	81,460	107,040	1,838	2,432	3,356	9,502
1966	15,560	59,859	782	946	4,103	6,310	117,171	747,754	141,454	506,547	83,320	109,483	1,878	2,486	3,452	9,775
1967	15,980	61,469	796	963	4,217	6,486	120,210	767,672	144,753	518,221	85,250	112,026	1,919	2,540	3,547	10,044
1968	16,420	63,143	811	981	4,329	6,657	122,200	788,508	148,053	530,176	87,270	114,673	1,961	2,595	3,642	10,312
1969	16,870	64,877	825	999	4,429	6,812	124,155	809,669	151,456	542,410	89,360	117,425	2,004	2,652	3,737	10,581
1970	17,330	66,671	841	1,017	4,511	6,938	127,242	830,675	154,961	554,911	91,530	120,280	2,050	2,713	3,833	10,852
1971	17,810	68,515	857	1,036	4,577	7,039	129,347	851,419	158,568	567,705	93,790	123,243	2,098	2,777	3,930	11,128
1972	18,310	70,412	873	1,056	4,627	7,116	132,436	871,854	162,178	580,779	96,120	126,305	2,149	2,845	4,029	11,407
1973	18,820	72,376	890	1,076	4,655	7,158	134,422	891,632	165,889	594,042	98,490	129,427	2,200	2,912	4,128	11,690
1974	19,350	74,429	907	1,097	4,652	7,154	137,359	910,367	169,601	607,375	100,900	132,560	2,246	2,973	4,228	11,973
1975	19,910	76,582	925	1,119	4,615	7,098	140,248	927,808	173,313	620,701	103,200	135,666	2,285	3,024	4,329	12,258
1976	20,500	78,840	943	1,141	4,539	6,980	143,030	943,793	177,025	633,961	105,600	138,726	2,316	3,065	4,430	12,543
1977	21,110	81,187	962	1,164	4,431	6,815	145,793	958,438	180,736	647,210	107,900	141,748	2,341	3,097	4,531	12,831
1978	21,730	83,573	982	1,188	4,320	6,643	148,662	972,138	184,549	660,624	110,200	144,764	2,363	3,127	4,636	13,126
1979	22,340	85,933	1,002	1,212	4,242	6,524	151,627	985,467	188,365	674,450	112,500	147,823	2,389	3,161	4,745	13,435
1980	22,940	88,221	1,023	1,237	4,225	6,498	154,651	998,877	192,386	688,856	114,900	150,958	2,422	3,205	4,861	13,763
1981	23,510	90,425	1,044	1,263	4,280	6,583	157,721	1,012,409	196,612	703,909	117,300	154,178	2,465	3,262	4,984	14,112
1982	24,060	92,557	1,065	1,289	4,398	6,764	160,877	1,026,029	200,944	719,533	119,800	157,464	2,516	3,330	5,113	14,479
1983	24,600	94,617	1,088	1,316	4,561	7,015	164,105	1,040,011	205,478	735,585	122,400	160,781	2,575	3,408	5,249	14,864
1984	25,120	96,613	1,112	1,345	4,741	7,291	167,375	1,054,667	210,015	751,855	124,900	164,082	2,642	3,497	5,391	15,264
1985	25,620	98,556	1,137	1,376	4,917	7,562	170,715	1,070,175	214,552	768,185	127,300	167,332	2,716	3,594	5,537	15,677
1986	26,110	100,440	1,165	1,410	5,084	7,819	174,129	1,086,733	219,090	784,527	129,800	170,521	2,797	3,701	5,687	16,103
1987	26,590	102,277	1,196	1,446	5,248	8,070	177,610	1,104,193	223,727	800,913	132,200	173,658	2,885	3,818	5,842	16,541
1988	27,070	104,123	1,226	1,483	5,410	8,320	181,161	1,121,957	228,265	817,364	134,500	176,746	2,979	3,942	5,999	16,987
1989	27,570	106,052	1,253	1,516	5,576	8,575	184,783	1,139,192	232,905	833,929	136,800	179,794	3,076	4,071	6,159	17,439
1990	28,110	108,118	1,277	1,544	5,749	8,841	188,477	1,155,305	237,545	850,638	139,100	182,812	3,175	4,202	6,319	17,891
1991	28,690	110,341	1,294	1,566	5,928	9,117	192,235	1,170,052	242,286	867,481	141,400	185,793	3,275	4,334	6,479	18,344
1992	29,300	112,709	1,308	1,582	6,111	9,399	196,080	1,183,617	247,029	884,425	143,600	188,740	3,377	4,469	6,638	18,796
1993	29,950	115,203	1,320	1,596	6,296	9,683	200,000	1,196,360	251,772	901,459	145,900	191,671	3,480	4,605	6,797	19,247
1994	30,620	117,787	1,334	1,614	6,482	9,968	203,999	1,208,842	256,515	918,570	148,100	194,615	3,584	4,742	6,956	19,695
Correlation	1.000		1.000		1.000		0.990		1.000		1.000		1.000		1.000	

Fuelwood Production versus Population in RWEDP Countries (cont)

Source: FAO

The table shows the correlation between the fuelwood production and population as provided by FAO statistics. It shows that this correlation is 1 for all countries except China.
The correlation between fuelwood production and population is calculated by using a formula to calculate the correlation over the whole range of years for which data are available.

	Myanmar		**Nepal**		**Pakistan**		**Philippines**		**Sri Lanka**		**Thailand**		**Vietnam**		**RWEDP**	
	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*	Prod. *1000 cum*	Pop. *1000*
1961	9,475	22,207	8,841	9,611	10,018	51,273	15,190	28,380	4,912	10,136	15,070	27,189	14,470	35,393	408,020	1,474,097
1962	9,674	22,674	9,005	9,791	10,286	52,650	15,650	29,228	5,033	10,385	15,530	28,006	14,750	36,081	417,023	1,505,879
1963	9,878	23,152	9,189	9,979	10,570	54,086	16,120	30,113	5,156	10,639	15,990	28,848	15,050	36,803	426,178	1,539,376
1964	10,090	23,648	9,341	10,174	10,864	55,584	16,620	31,045	5,282	10,899	16,480	29,725	15,350	37,557	436,527	1,574,888
1965	10,310	24,167	9,559	10,374	11,170	57,145	17,150	32,030	5,411	11,164	16,990	30,641	15,670	38,341	446,293	1,612,567
1966	10,540	24,711	9,748	10,580	11,485	58,772	17,700	33,071	5,543	11,437	17,520	31,596	16,010	39,152	456,266	1,652,479
1967	10,790	25,278	9,942	10,793	11,812	60,461	18,290	34,160	5,678	11,716	18,070	32,588	16,350	39,991	467,604	1,694,408
1968	11,040	25,866	10,153	11,016	12,149	62,195	18,890	35,282	5,813	11,994	18,630	33,612	16,710	40,864	478,071	1,737,874
1969	11,300	26,475	10,365	11,252	12,496	63,948	19,490	36,414	5,943	12,262	19,220	34,666	17,080	41,775	488,730	1,782,217
1970	11,560	27,102	10,545	11,504	12,843	65,706	20,100	37,540	6,065	12,514	19,820	35,745	17,470	42,729	500,701	1,826,897
1971	11,840	27,748	10,790	11,772	13,181	67,474	20,690	38,656	6,178	12,748	20,430	36,847	17,880	43,728	511,966	1,871,835
1972	12,120	28,412	11,050	12,057	13,538	69,263	21,290	39,764	6,284	12,965	21,050	37,967	18,300	44,767	524,354	1,916,969
1973	12,410	29,087	11,330	12,358	13,886	71,071	21,870	40,861	6,385	13,174	21,680	39,098	18,740	45,838	535,795	1,961,800
1974	12,700	29,766	11,610	12,675	14,244	72,892	22,450	41,943	6,487	13,384	22,300	40,231	19,180	46,928	548,214	2,005,747
1975	12,990	30,441	11,920	13,006	14,602	74,734	23,020	43,010	6,593	13,603	22,930	41,359	19,630	48,030	560,510	2,048,439
1976	13,280	31,112	12,230	13,354	14,960	76,583	23,580	44,054	6,704	13,832	23,550	42,478	20,090	49,139	572,777	2,089,601
1977	13,560	31,780	12,560	13,716	15,328	78,464	24,130	45,081	6,819	14,069	24,160	43,587	20,550	50,259	584,911	2,129,446
1978	13,850	32,449	12,900	14,091	15,718	80,468	24,680	46,113	6,937	14,314	24,770	44,673	21,010	51,390	597,307	2,168,681
1979	14,140	33,128	13,250	14,478	16,160	82,719	25,260	47,185	7,059	14,564	25,350	45,720	21,480	52,540	609,909	2,208,339
1980	14,430	33,821	13,610	14,874	16,665	85,299	25,860	48,317	7,182	14,819	25,900	46,718	21,960	53,711	623,015	2,249,174
1981	14,730	34,529	13,980	15,279	17,244	88,240	26,510	49,521	7,308	15,079	26,420	47,658	22,450	54,905	636,558	2,291,352
1982	15,040	35,253	14,360	15,693	17,876	91,506	27,190	50,789	7,436	15,343	26,910	48,544	22,940	56,122	650,525	2,334,695
1983	15,360	35,995	14,740	16,114	18,571	95,033	27,890	52,093	7,565	15,608	27,390	49,398	23,450	57,361	665,022	2,379,199
1984	15,680	36,758	15,130	16,542	19,287	98,720	28,580	53,395	7,690	15,867	27,860	50,253	23,960	58,620	679,483	2,424,769
1985	16,020	37,544	15,520	16,975	20,024	102,490	29,260	54,668	7,810	16,114	28,350	51,129	24,490	59,898	693,968	2,471,275
1986	16,370	38,353	15,920	17,412	20,782	106,331	29,920	55,902	7,924	16,350	28,850	52,037	25,020	61,194	708,648	2,518,833
1987	16,720	39,187	16,320	17,854	21,540	110,248	30,570	57,107	8,033	16,574	29,370	52,967	25,550	62,510	723,401	2,567,363
1988	17,090	40,043	16,730	18,305	22,309	114,190	31,210	58,304	8,138	16,792	29,880	53,892	26,100	63,856	738,067	2,616,304
1989	17,460	40,919	17,150	18,770	23,077	118,097	31,860	59,521	8,243	17,007	30,370	54,773	26,670	65,246	752,952	2,664,901
1990	17,840	41,813	17,590	19,253	23,824	121,933	32,540	60,779	8,349	17,225	30,820	55,583	27,260	66,689	767,975	2,712,626
1991	18,230	42,724	18,050	19,755	24,551	125,667	33,230	62,084	8,456	17,447	31,220	56,312	27,880	68,188	783,204	2,759,205
1992	18,630	43,652	18,520	20,276	25,267	129,314	33,950	63,427	8,565	17,671	31,590	56,972	28,510	69,737	798,475	2,804,786
1993	19,030	44,596	19,010	20,812	25,972	132,941	34,690	64,800	8,674	17,897	31,930	57,585	29,160	71,324	813,981	2,849,779
1994	19,440	45,555	19,500	21,360	26,699	136,645	35,430	66,188	8,785	18,125	32,260	58,183	29,810	72,931	829,514	2,894,820
Correlation	1.000		1.000		1.000		1.000		1.000		1.000		1.000		0.999	

ANNEX 3

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