ASIA-PACIFIC FORESTRY SECTOR OUTLOOK STUDY II

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BIOMASS ENERGY IN THE ASIA-PACIFIC REGION: CURRENT STATUS, TRENDS AND FUTURE SETTING

by

Tini Gumartini[1]

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC

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[1] During September to December 2007, Tini Gumartini worked as a Consultant for the Food and Agriculture Organization of the United Nations (FAO), Rome.

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INFORMATION NOTE ON THE ASIA-PACIFIC FORESTRY SECTOR OUTLOOK STUDY

The Asia-Pacific Forestry Sector Outlook Study (APFSOS) is a wide-ranging initiative to gather information on, and examine, the evolution of key forestry issues as well as to review important trends in forests and forestry. The main purpose of the study is to provide a better understanding of the changing relationships between society and forests and thus to facilitate timely policy reviews and reforms in national forest sectors. The specific objectives are to:

1. Identify emerging socio-economic changes impacting on forest and forestry
2. Analyze probable scenarios for forestry developments to 2020
3. Identify priorities and strategies to address emerging opportunities and challenges

The first APFSOS was completed in 1998, with an outlook horizon to 2010. During its twenty-first session, held in Dehradun, India, in April 2006, the Asia-Pacific Forestry Commission (APFC) resolved to update the outlook extending the horizon to 2020. The study commenced in October 2006 and is expected to be completed by September 2009.

The study has been coordinated by the Food and Agriculture Organization of the United Nations (FAO), through its regional office in Bangkok and its headquarters in Rome, and implemented in close partnership with APFC member countries with support from a number of international and regional agencies. The Asian Development Bank (ADB), the International Tropical Timber Organization (ITTO), and the United Kingdom's Department for International Development (DFID) provided substantial financial support to implement the study. Partnerships with the Asia-Pacific Association of Forest Research Institutes (APAFRI) and the Secretariat of the Pacific Community (SPC) supported the organizing and implementing of national focal points' workshops and other activities, which have been crucial to the success of this initiative. The contributions of many other individuals and institutions are gratefully acknowledged in the main APFSOS report.

Working papers have been contributed or commissioned on a wide range of topics. These fall under the following categories: country profiles, sub-regional studies and thematic studies. Working papers have been prepared by individual authors or groups of authors and represent their personal views and perspectives; therefore, opinions expressed do not necessarily reflect the views of their employers, the governments of the APFC member countries or of FAO. Material from these working papers has been extracted and combined with information from a wide range of additional sources to produce the main regional outlook report.

Working papers are moderately edited for style and clarity and are formatted to provide a measure of uniformity, but otherwise remain the work of the authors. Copies of these working papers, as well as more information on the Asia-Pacific Forestry Sector Study, can be obtained from:

Mr. Patrick Durst
Senior Forestry Officer
FAO Regional Office for Asia and the Pacific
39 Phra Atit Road
Bangkok 10200
THAILAND
Ph. (66-2) 697 4000
Fax: (66-2) 697 4445
Email: patrick.durst@fao.org

1. INTRODUCTION

Background

Asia Pacific Forestry Sector Outlook Study (APFSOS) is part of the global and regional outlook studies carried out by FAO to assess and analyse the status, trends and outlook for forestry. Outlook studies highlight long-term trends in the sector, assess the main forces that shape those trends and then explore future prospects and opportunities. The first Outlook Study on biomass energy was completed in 1997 by the Regional Wood Energy Development Programme in Asia (RWEDP) and used their 16 member countries in Asia as their main focus of the study: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam. The objective of the study was to address the present wood energy situation at national, regional and international levels and possible wood energy scenarios for traditional as well as modern uses. The first Outlook Study acknowledged the importance of wood energy for the 16 member countries studied as their main sources of energy; most of the woodfuel, about two-thirds, originated from non-forest land, and was not derived from forests as previously believed. It also recognized the insufficient volume of data on wood energy to enable woodfuel to be included in common energy modelling and the energy balance.

The Asia-Pacific region has continued to demonstrate rapid economic growth, mostly among several industrialized countries in the region, such as Japan, Australia and Republic of Korea but also India and China, which have become vast emerging economies. High income, increase in population and urbanization have led to the continuation of this pace of economic growth that in turn will lead to the acceleration in demand for energy for domestic purposes, services and transportation. The impact of this rapid growth is increased by changes in energy consumption per capita, as half of the world population resides in this region of which almost two-thirds lives in rural areas; thus biomass has been a predominant energy source, mostly for domestic uses.

Rapid economic growth will be accompanied by higher income and improvement of accessibility to more refined and convenient sources of energy, resulting in a move up the energy ladder. However, as the rate of economic growth varies amongst countries, benefits from economic growth will exclude some segments of society, especially in rural areas, and high dependence on traditional biomass energy is likely to persist in many countries. As economic growth continues, one would expect a shift from biomass to fossil fuels. However, increasing demand and prices coupled with the growing concern on climate change is likely to alter the pattern of energy use.

Objective of the study

Since the completion of APFSOS I in 1998, the overall social, economic, environment, political and institutional situation within and outside this region has undergone major changes. In response to these changes, a better understanding of what is likely to happen and how this sector is likely to develop in the 15 years to come is very important. It is also important to know the extent of the changes since the completion of the first study. Therefore, the objectives of this second Outlook study in the biomass energy sector are to:

- Assess the current situation and trends as regards biomass energy consumption
- Analyze the driving forces influencing the changes
- Assess the probable scenarios of the development of different biomass energy segments in the Asia-Pacific region

Scope and coverage

Emerging global interest in renewable energy resources has increased their role, including that of biomass. Biomass is used predominantly in developing countries, mostly in the form of wood and agricultural residues as the most common fuel for cooking and heating. Considering the importance of this source of energy in the Asia-Pacific region, where most countries still have a predominantly rural population, wood-based energy is the main focus in this study.

APFSOS II covers 33 countries (Figure 1), and for the purpose of this study, they are grouped into four sub-regions, namely East Asia, South Asia, Southeast Asia and the Pacific.

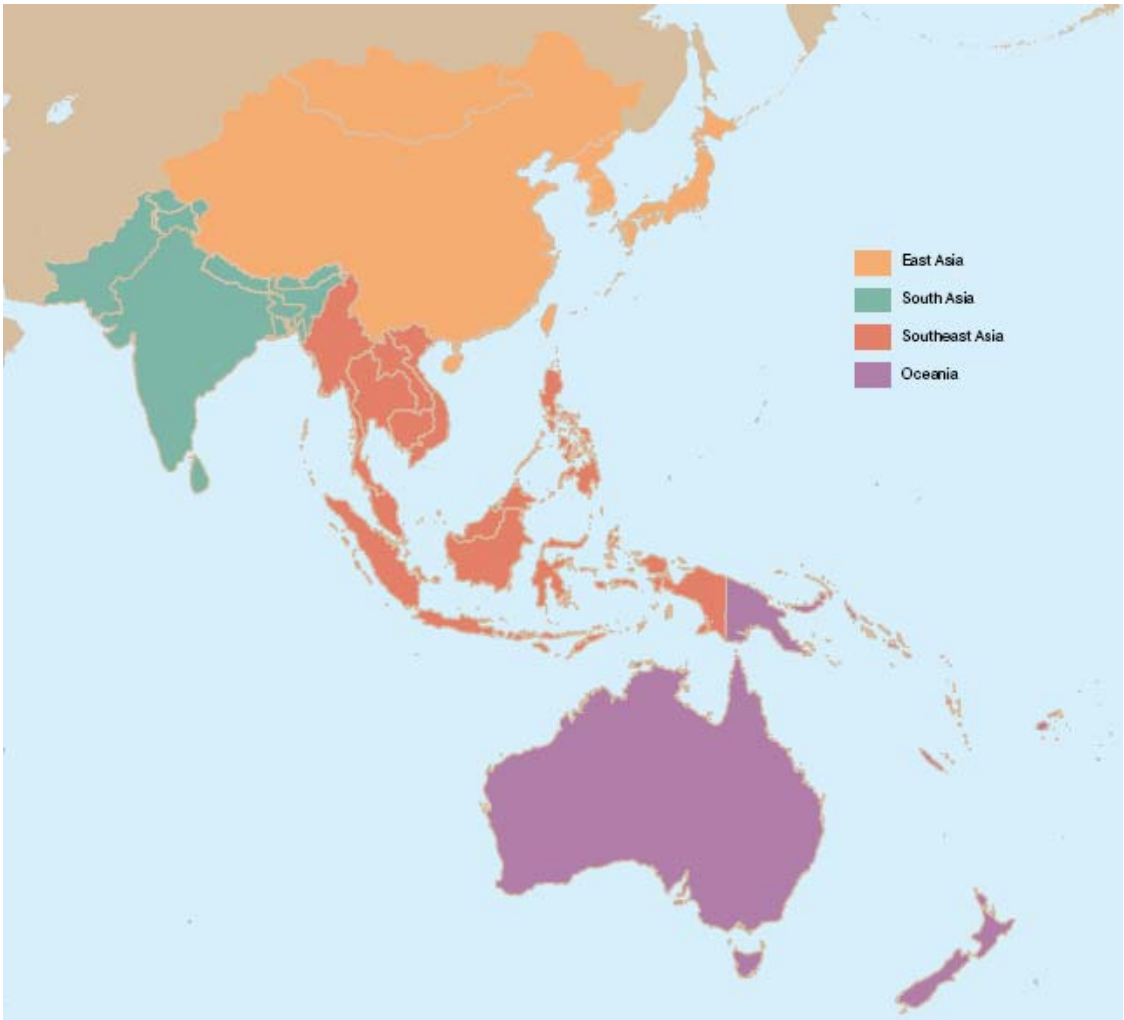


Figure 1. Countries covered in the Asia Pacific Forestry Sector Outlook Study II

2. DEFINITION AND SOURCE OF BIOMASS ENERGY

Definition of biomass energy

Based on FAO's Unified Bioenergy Terminology (FAO, 2004), the conceptual view of bio-energy systems is shown in Figure 2, describing the flow of bio-energy production from biomass as a source of energy.

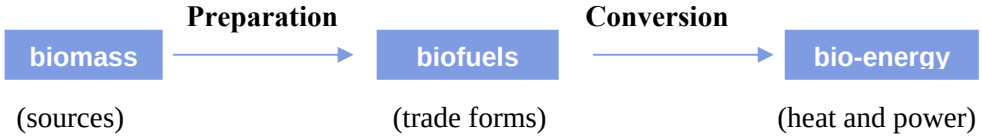


Figure 2. Bio-energy production flow

Bio-energy can be defined as energy obtained from biological and renewable sources (biomass); bio-energy may be derived in the form of heat or transformed into electricity for distribution. Biomass also can be transformed into biofuels, which are portable feedstock for use in the generation of bio-energy. Biofuels are defined as feedstock intended for the production of bio-energy, produced directly or indirectly from biomass. Biofuels can be in solid form (fuelwood, charcoal, wood pellets, briquettes etc.) or liquid (bioethanol, biodiesel).

With the emerging development on bio-energy today using more modern technology, biomass energy can be divided into traditional biomass and modern bio-energy. Traditional biomass is the main source of energy used in developing countries primarily for cooking and space heating at the household level, mostly using three-stone stoves, or in some areas improved cooking stoves. This source of energy is in the form of woodfuel (including fuelwood and charcoal), crop residues and animal dung and is often collected by women and children on a daily basis. In some areas traditional biomass is also traded within villages and among villages or with nearer townships. Another characteristic of traditional biomass is using traditional technology with low efficiency due to poor design, uncontrolled and open burning, which have important health implications. Modern bio-energy, is used mostly for the generation of electricity or transportation. Liquid biofuels for transportation such as ethanol and biodiesel are examples of the emerging energy alternatives.

Table 1 describes in detail the key differences between traditional and modern biomass in terms of input, output and conversion technology. Traditional forms of biomass use are characterized by low capital, low conversion efficiency, poor utilization of fuel, and poor emission controls whereas modern forms of biomass use are characterized by higher capital, higher conversion efficiency, better utilization of fuel, and better emission controls (Rajagopal and Zilberman, 2007). Transformation of low efficiency fuels to high efficiency convenient fuels involves substantial investments, and often the transformation process involves loss of energy.

Table 1. Comparison between traditional and modern bio-energy systems (Rajagopal and Zilberman, 2007)

Characteristics of technology	Traditional	Modern
Fuel	Mostly gathered or collected and in some cases purchased	Commercially procured
Capital	Low capital cost	High capital cost
Labour	High labour intensity at household level in collection of fuel	Low labour intensity at household level but overall high labour intensity compared to other energy sources
Conversion process	Low efficiency and poor utilization of biomass	Higher efficiency and higher utilization of biomass
Energy uses	Energy for cooking and heating in poor households in developing countries	Commercial heating, electricity and transportation
Emission controls	Poor emission controls	Controlled emissions
Co-product	No co-products	Commercially useful co-products

Sources of biomass energy

There are three types of biofuel sources: woodfuel, agrofuels and municipal by-products.[2] Woodfuel refers to all types of biofuels derived directly and indirectly from trees and shrubs grown on forest and non-forest lands, from silvicultural activities, harvesting and logging, as well as industrial by-products. Agrofuels are biofuels obtained as products of agriculture biomass and by-products from farming, and/or industrial processing of raw material (agro-industries). They cover mainly biomass materials derived directly from fuel crops and agricultural, agro-industrial and animal by-products. Municipal by-products refer to biomass by-products produced by urban populations (including residential, commercial, industrial and public). They consist of solid municipal by-products and gas/liquid municipal by-products produced in cities and villages. Biofuel classification is detailed in Tables 2 and 3.

[2] The term by-products includes the improperly termed solid, liquid and gaseous residues and wastes derived from biomass processing activities.

Table 2. Definition of biofuel classification (FAO, 2004)

Types of biofuels		Brief definition
Woodfuel	Direct woodfuel	Wood from forests, shrubs and other trees used as fuel
	Indirect woodfuel	Mainly solid biofuels produced from wood processing activities
	Recovered woodfuel	Wood used directly or indirectly as fuel, derived from socio-economic activities outside the forest sector
	Wood-based fuels	Mainly liquid and gaseous biofuels produced from woody biomass
Agrofuels	Fuel crops	Growing plants for the production of biofuels
	Agricultural by-products	Mainly by-products from crop harvesting and other kinds of by-products from agricultural activities left in the field
	Animal by-products	Primarily excreta from cattle, horses, pigs and poultry
	Agro-industrial by-products	Several kinds of biomass materials produced chiefly in food and fibre processing industries, such as bagasse and rice husks
Municipal by-products		Several kinds of solid and liquid municipal biomass materials produced in urban societies

Table 3. Biofuel classification scheme (FAO, 2004)

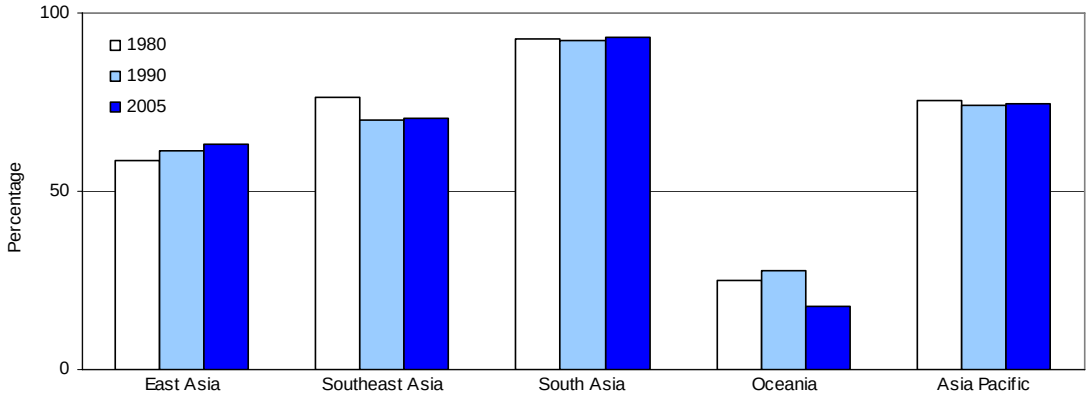
Production side, supply	Common groups	Users' side, demand examples
Direct woodfuel Indirect woodfuel Recovered woodfuel Wood-derived fuels	**WOODFUEL**	**Solid:** Fuelwood (wood in the rough, chips, sawdust, pellets), charcoal **Liquid:** black liquor, methanol, pyrolitic oil **Gases:** products from gasification and pyrolisis gases of above fuels
Fuel crops Agricultural by-products Animal by-products Agro-industrial by-products	**AGROFUELS**	**Solid:** straw, stalks, husks, bagasse, charcoal from the above biofuels **Liquid:** ethanol, raw vegetable oil, oil diester, methanol, pyrolitic oil from solid agrofuels **Gases:** biogas, producer gas, pyrolisis gases from agrofuels
Municipal by-products	**MUNICIPAL BY-PRODUCTS**	**Solid:** municipal solid wastes (MSW) **Liquid:** sewage sludge, pyrolitic oil from MSW **Gases:** landfill gas, sludge gas

Share of woodfuel in total roundwood production

The Asia-Pacific region had a high proportion of woodfuel in total roundwood production in 2005; around three-quarters of roundwood production was accounted for by woodfuel or the equivalent of 780 million m^3 out of 1,046 million m^3 of roundwood production (FAOSTAT, accessed in November 2007). The high share of woodfuel in total roundwood production indicates the importance of, as well as the heavy reliance on, woodfuel as a source of energy in Asia and the Pacific. South Asia has the highest share compared to other sub-regions, where more than 90 percent of wood production was woodfuel, followed by Southeast Asia where woodfuel production accounted for 70 percent. Compared to 1980, the share of woodfuel production in this region slightly declined from 75.3 percent in 1980 to 74.6 percent in 2005. Southeast Asia and Oceania contributed to this declining trend as presented in Figure 3. This slight decline in the past two decades indicated that woodfuel was still playing a vital role in meeting energy demand in most of the countries in the region.

The share of woodfuel production in 2005 had declined in most of the countries in this region compared to the share in 1980. In some countries, the decline happened both in share and absolute terms, for example in Indonesia, Japan, Republic of Korea, Malaysia, Mongolia and Sri Lanka, while others experienced increase in absolute terms as in the case of Lao PDR, Nepal, Pakistan and Vietnam.

Amongst all of the countries in this region, Bangladesh, Cambodia and Bhutan have the highest share – more than a 95 percent share of woodfuel in total roundwood production (Figure 4). Several countries showed the smallest share, with less than 10 percent, as some countries have limited sources, for example in the case of Kiribati, Maldives, Tonga, New Caledonia and Singapore, they depend entirely on importing woodfuel to fulfil the demand.



	East Asia	Southeast Asia	South Asia	Oceania	Asia Pacific
1980	58.5	76.6	92.9	24.9	75.3
1990	61.4	70.1	92.3	27.9	74.0
2005	63.3	70.4	93.1	17.6	74.6

Figure 3. Share of woodfuel production in total roundwood production in the Asia-Pacific region

Source: FAOSTAT (accessed in November 2007)

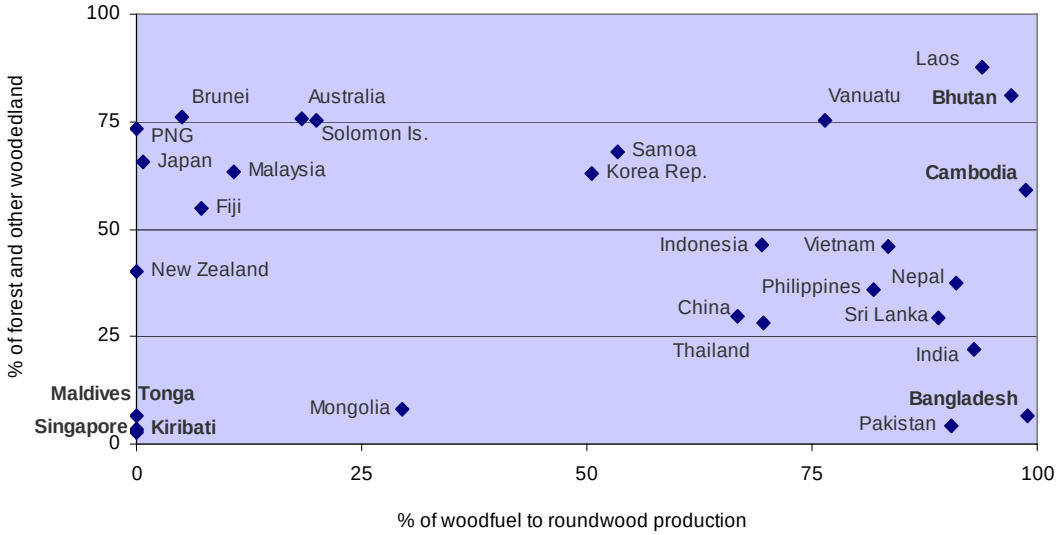


Figure 4. Percentage of woodfuel to roundwood production vs percentage of forest and other wooded land

Source: FAO (2005); FAOSTAT (accessed in November 2007)

The importance of woodfuel can also be explained by looking at its percentage in total roundwood removal. In 2005 total roundwood removal for the Asia-Pacific region was 1,046 million m^3, of which around 74.6 percent (or approximately about 780 million m^3) was woodfuel, and the remainder was industrial roundwood (Figure 5).

In general, roundwood removal in the Asia-Pacific region declined slightly at about 0.1 percent annually for the period 1990-2005. This decline was mostly attributed to Southeast Asia with an average rate of change of about 1.3 percent per annum, where most of the countries experienced high decline of primary forest and forest plantation extent, such as in Brunei, Cambodia, Indonesia, Malaysia, and the Philippines, with a change rate of 0.8-9.6 percent annually for the same period. In the case of South Asia and the Pacific, total roundwood removal increased with an annual rate of change of about 0.6 and 2.8 percent, respectively. The increment was most likely caused by increase in forest plantation area in most of the countries in the two sub-regions. For example in the Pacific, the forest plantation area in Australia increased at the rate of 3.7 percent annually during the period 1990-2005, followed by New Zealand, Fiji and Papua New Guinea (2.6, 1.6 and 1.6 percent respectively), while in South Asia, India led with an annual rate of change of about 3.4 percent, followed by Pakistan, Bangladesh and Nepal (Figure 6).

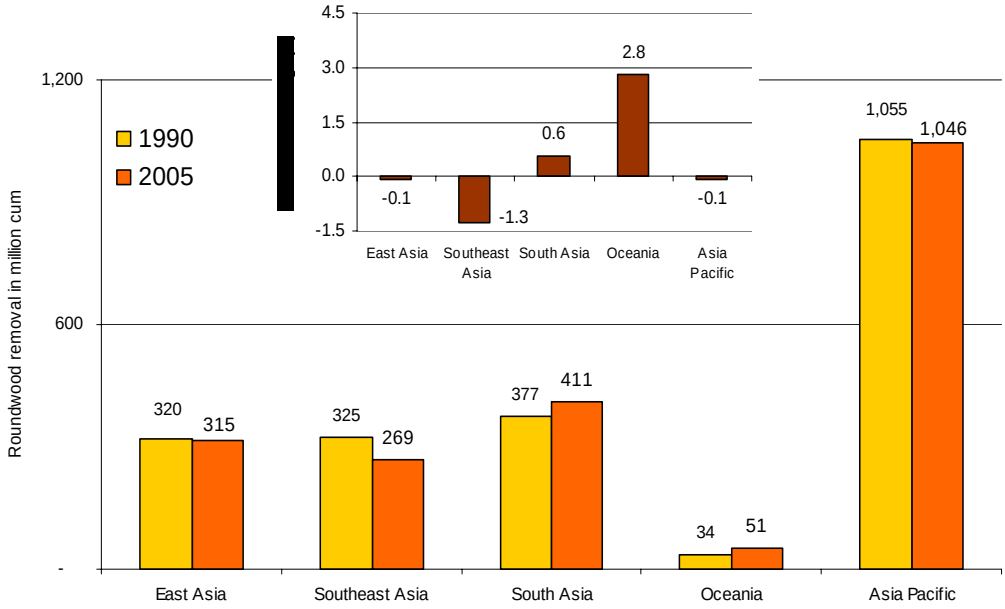


Figure 5. Roundwood removal in the Asia-Pacific region from 1990-2005

Source: FAOSTAT (accessed in November 2007).

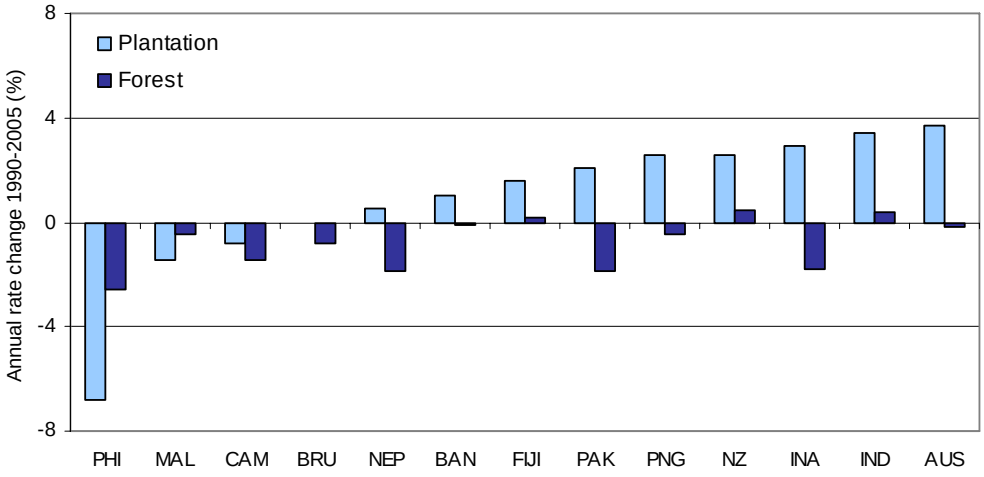


Figure 6. Annual rate change of forest and plantation extent in various countries

Source: FAO (2005).

3. CURRENT STATUS AND TRENDS OF BIOMASS ENERGY

Role of biomass as an energy resource in global, regional and local contexts

Due to the oil crisis in the 1970s there has been, and still are, growing concerns in many countries regarding security of energy supply, higher fossil fuel prices, environmental degradation, climate change and the sustainability of the energy system. These concerns have led to increased global attention in supporting the development of alternative energy based on renewable energy sources (Tomaselli, 2007; Best and Christensen, 2003). The potential of renewable energy to reduce dependency on conventional energy has been given serious consideration in recent years. Biomass is regarded as a renewable energy resource that offers potential opportunity to contribute to the global primary energy supply. The reason why biomass currently attracts attention is its renewability, potential for decentralized production and more importantly its carbon neutrality and hence its role in climate change mitigation. Furthermore, it can be transformed into electricity, heat and power and used in forms which are more convenient.

Statistical data from the International Energy Agency (OECD/IEA, 2007) show that conventional energy resources, such as oil, are still the most important sources of energy followed by coal and gas, accounting for approximately 80 percent of Total Primary Energy Supply (TPES). The next important contributor is combustible renewable energy (CRE),[3] which contributes around 10 percent of the world's TPES share (Figure 7). This share is different between developed and developing countries, where the share of CRE is higher in developing countries than in developed countries – 17 percent compared to 3 percent (Figure 8). This figure reflects the high reliance of developing countries on CRE.

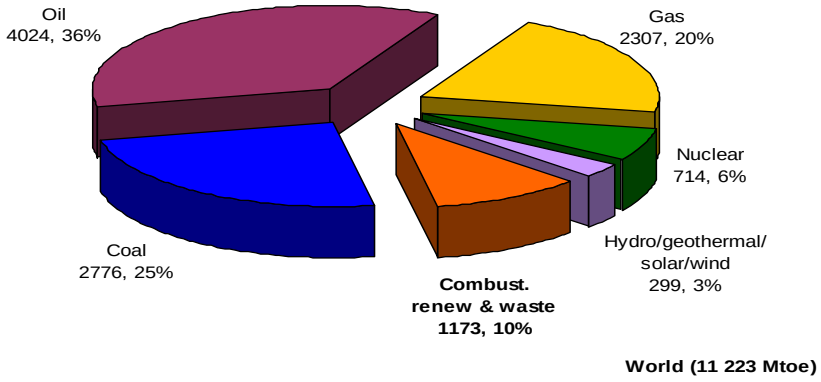


Figure 7. Share of CRE sources to TPES in 2004

Source: OECD/IEA (2007)

[3] CRE and waste comprise solid biomass, liquid biomass, biogas, industrial waste and municipal waste (OECD/IEA, 2007).

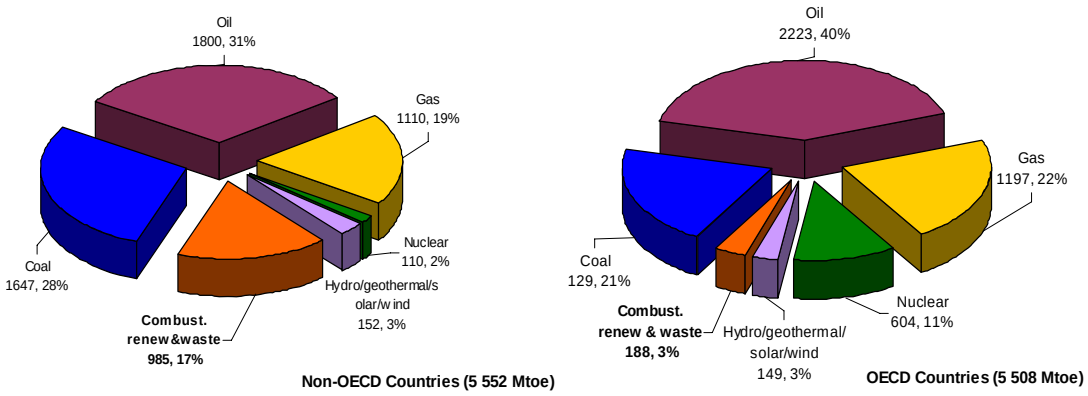


Figure 8. Comparison between developing (non-OECD) and developed (OECD) countries regarding the share of CRE in 2004

Source: OECD/IEA (2007).

CRE, or traditional biomass energy, constitutes 80 percent of the total renewable energy consumed mainly in developing countries while other forms of modern renewable energy, such as hydro, geothermal, solar and wind power are consumed mainly in developed countries. Table 4 presents the percentage share of CRE to the total primary energy supply and also to the total renewable energy from different regions in the world. Asia and China (together with Africa) contribute the largest share compared to other regions. If we compare the contribution within the Asia-Pacific region, CRE is an important energy resource in South Asia where 38 percent of the total primary energy supply comes from it (Figure 9). In Southeast Asia and China, the share of CRE is far less compared to South Asia (15 percent and 14 percent respectively).

Figure 9 also compares the production share of each category of CRE. Primary solid biomass contributes the major share compared to other types of CRE in the Asia-Pacific region, and also in the world in general. It accounted for almost 100 percent in South Asia and in Asia in general, whereas in Southeast Asia and China, besides solid biomass's place as the highest share, biogas contributes a small share to total production. In the Pacific region, even though solid biomass still contributes the major share (71.5 percent), it also produces more types of CRE, for example municipal and industrial waste, solar thermal and geothermal power as other important energy sources.

Table 4. 2004 share of CRE from different regions

Region	TPES	Of which renewable	Share of renewable in TPES	Share of the main fuel categories in total renewables		
				Hydro	Geothermal /solar/ wind	CRE and waste
	Mtoe	Mtoe	%	%	%	%
Africa	586	287	49	2.6	0.4	97.1
Latin America	486	140	28.9	36.1	1.4	62.4
Asia*	1,289	411	31.8	4	3.6	92.4
China**	1,627	251	15.4	12.1	0	87.9
Non-OECD Europe	104	11	10.6	43.2	2.5	54.3
Former USSR	979	30	3	71.4	1.2	27.3
Middle East	480	3	0.7	43.4	24.4	32.2
OECD	5,508	315	5.7	34.6	12	53.4
World	**11,059**	**1,404**	**13.1**	**16.7**	**4**	**79.4**

* Asia exclude China; ** China includes People's Republic of China and Hong Kong
Source: OECD/IEA (2007).

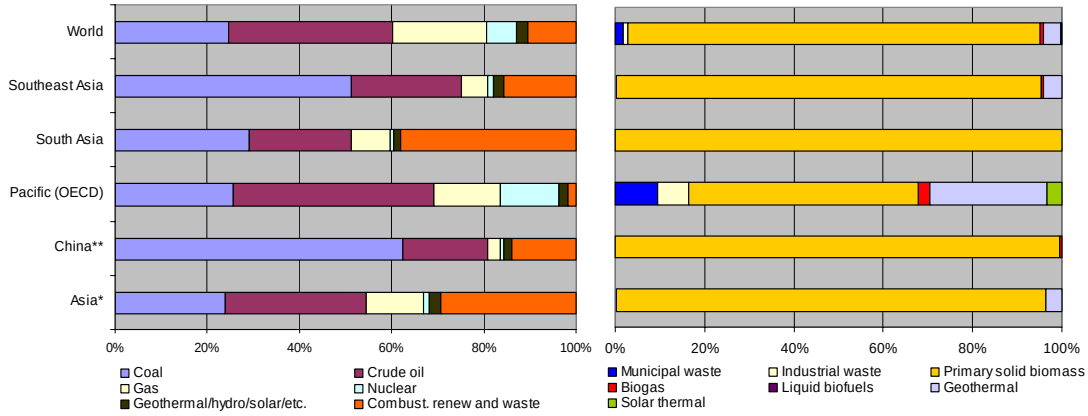


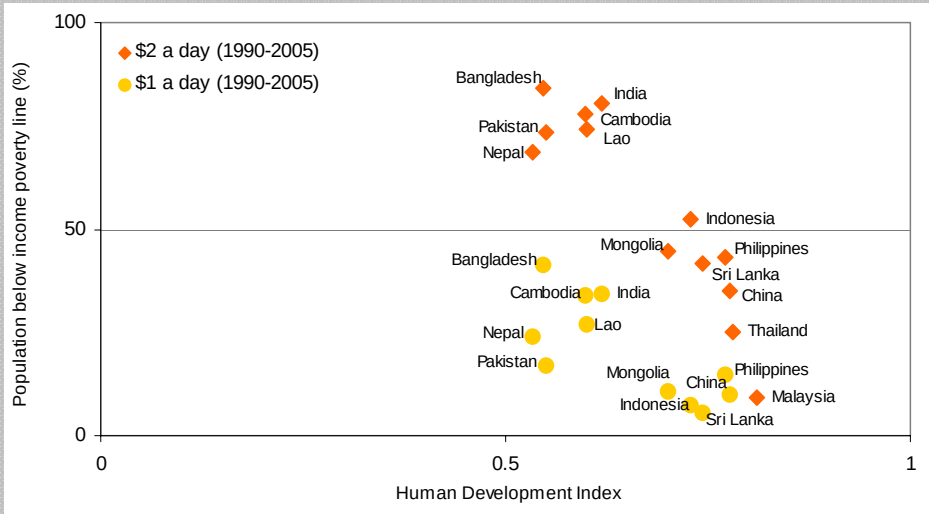
Figure 9. 2004 share of combustible renewable and waste and primary solid biomass

Note**: *** Asia excluding China; **China includes People's Democratic of China and Hong Kong
Source: OECD/IEA (2007).

Biomass energy, particularly fuelwood, charcoal and agricultural waste, continue to play a significant role as energy resources. In 2002, out of 39 EJ (exajoules [1 billion joules]) of traditional biomass use, 21 EJ, or about 54 percent, was consumed in the form of woodfuel and the remainder came from manure (Smeets and Faaij, 2007). Traditional biomass remains a dominant energy source, especially for most rural households in developing countries, largely on account of its low cost and easy accessibility. High dependence on traditional biomass as a source of energy and limited access to commercial and modern fuels is a manifestation of poverty (IEA, 2002). Based on the current UN world population data (UN, 2007) in 2005, 51 percent of the world's population resides in rural areas; in the Asia-Pacific region, which shares 55 percent of the total world population, 67 percent or approximately 2.2 billion people

live in rural areas. Although this region is on track to reach the MDG target of reducing poverty, about 641 million people are still living on less than US$1 per day, for example in Bangladesh, Cambodia and India (UNDP, 2007; UNESCAP, 2007) (Box 1). For this segment of society, traditional biomass continues to play a vital role as the most important domestic energy source especially for cooking and space heating.

Box 1. Population in Poverty: Proportion of Population Living in Poverty from Selected Countries in Asia and the Pacific (1990-2005)



Note: Malaysia and Thailand, the proportion of $1 a day is accounted for less than 2 percent
Source: UNDP (2007)

However, in current development, biomass energy is dominantly used not only in developing countries but also in developed countries as an important industrial energy option. The share of biomass shows large variation amongst countries as well, for example at present Finland derives over 20 percent of total primary energy supply from biomass, while Sweden, Austria and Australia have lower shares, about 17, 11 and 3.3 percent, respectively (Saddler et al., 2004).

Box 2. Human Development Index

The Human Development Index (HDI) is a summary of human development. It measures the average achievements in a country in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight)
- A decent standard of living, as measured by GDP per capita purchasing power parity (PPP) terms in dollars

Source: UNDP (2007).

The governments of many developed countries encourage the use of biomass energy (including other renewable energy technologies) to use as an alternative energy source and to increase the share of modern biomass energy in the energy mix (Best and Christensen, 2003). Policy makers recognize that there is economic value added, especially in terms of the potential for increasing employment opportunities, enhancing energy security, generating income through job creation and the development of a strong export industry, as well as the environmental benefit (Domac et al., 2005).

The share of biomass energy in total energy consumption varies among countries, but in general the poorer the country the higher the dependency on biomass energy. A difference in energy use exists between rural and urban households, between high and low income groups within a country as well as among countries in the region. The main factors contributing to this difference are urbanization, economic development and standard of living. Other factors

such as climate and cultural practice can also contribute to the disparities among the users (Dzioubinski and Chipman, 1999; Victor and Victor, 2002).

Rural and poor urban households are the main users as the other alternative energy sources are far too expensive; commercial energy requires a well-developed infrastructure which is absent in many rural areas. This condition makes traditional biomass energy in most cases the only affordable and accessible energy source for rural as well as urban poor households. In many areas, biomass energy provides employment, not only for men but also for women and children. Collection is carried out not only for meeting household daily energy needs but also for marketing to earn a daily livelihood; thus it becomes an important source of income, especially for low income households. Access to clean and affordable energy is essential for rural and urban poor communities, through the supply of heat, light and power as well as for other benefits such as the generation of income and health improvement.

Biomass energy can make an important contribution if the resource is produced and used in a sustainable way and supported by a readily available market. Currently, the contribution of this energy source in the commercial market is low as it is being constrained by costs, uncompensated benefits and unsustainable biomass production. Therefore governing markets to maintain sustainable biomass production might increase its contribution in order to lessen dependence on fossil fuel, enhance security of energy, increase local and regional employment opportunity and increase supply diversity which can improve options to meet specific users, particularly for rural areas in developing countries (IEA, 2002b).

Increased awareness of the need to mitigate climate change has renewed attention on the role of biomass energy in both developing and developed countries. Biomass energy offers environmental and social benefits, for example its ability to be converted into electricity, heat, liquid and gaseous fuels that will benefit society. Biomass is a carbon neutral form of energy which offers a potential alternative source of energy as fossil fuel substitution that will contribute to mitigating climate change.

Current situation of woodfuel consumption in the world and the Asia-Pacific region

The current situation of woodfuel consumption (which includes fuelwood and charcoal) discussed in this section, as well as projection in the following section were mainly based on an extensive study carried out by FAO. This study produced a global projection of woodfuel consumption using analytical models. The models included a number of explanatory variables: a) income, using GDP PPP in 1997 US dollars; b) forest area, based on FAO State of the World Forests 1997; c) land area, based on FRA 1990 Global synthesis, State of the World Forests 1997 or FRA 2000 for UN-ECE countries; d) oil production, using data from US Energy Information Administration (in barrels/cap/yr, 1997); e) temperature, based on NOAA Global historical climatology network; and f) percentage of the population living in urban areas, using World Urbanisation Prospects 1996 (FAO, 2003).

The total world woodfuel consumption in 2005 was about 1.9 billion m^3 and the Asia-Pacific region shares 41 percent, or equivalent to 787 million m^3, of the world total consumption (Figure 10). Fuelwood accounts for 750 million m^3, while charcoal accounts for 6.1 million tonnes. For the past two decades compared to other regions, the share of total woodfuel consumption of this region to world consumption has always been high, accounting for an average of 48 percent. High population in this region is likely to be one of plausible factors that contribute to the high share of woodfuel consumption. The Asia-Pacific region has been a home for over half of the world population, housing three of the most populous countries in the world – China, India and Indonesia. Almost two-thirds of this population live in rural areas, where traditional biomass is the most important source of energy.

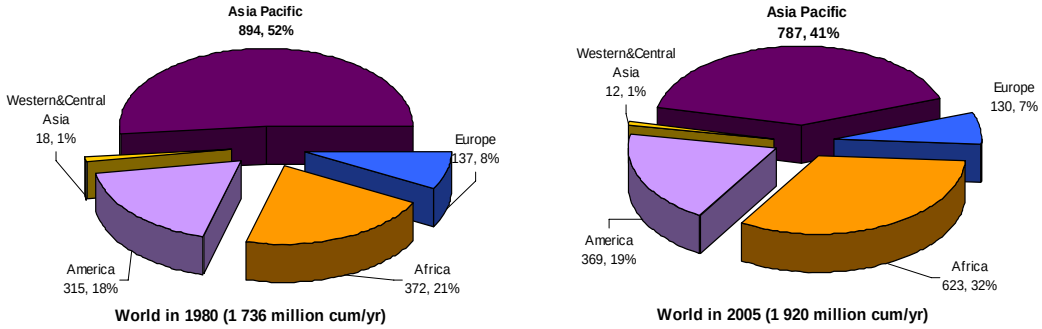


Figure 10. Share of woodfuel consumption for the Asia-Pacific region in 1980 and 2005

Source: FAO (2003)

However, consumption has been decreasing over time evidenced in both absolute amount and share of woodfuel consumption from about 894 million m^3/year (52 percent) in 1980 to 787 million m^3/year (41 percent) in 2005. If we look at the annual rate of change, the Asia-Pacific region has experienced a sharp decline in the past 15 years, 0.7 percent during the period 1990-2005 compared to 0.2 percent in 1980-1990 (Figure 11). Compared to the world situation, woodfuel consumption has increased in absolute terms over time, although, there is a slight decline in annual rate of change during the period 1980-1990 (0.5 percent) compared to 1990-2005 (0.3 percent).

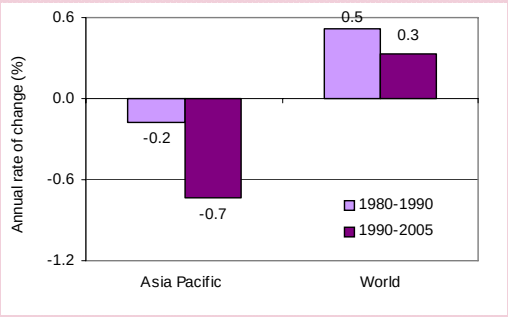


Figure 11. Annual rate of change of woodfuel consumption in Asia Pacific and the world

Figure 12 presents the current status of woodfuel consumption from sub-regions in 2005 compared to 1990 consumption. During 1990-2005, the woodfuel consumption in the Asia-Pacific region declined by almost 15 percent, from 48 percent in 1990 (879 million m^3) down to 41 percent in 2005 (787 m^3) with an average annual rate of change of about 0.7 percent. The major decline was contributed by East Asia followed by Southeast Asia with an average rate of change at 18 and 14 percent respectively in the same period with a comparable average rate of change of about 2 percent per annum, whereas South Asia and the Pacific islands increased their consumption.

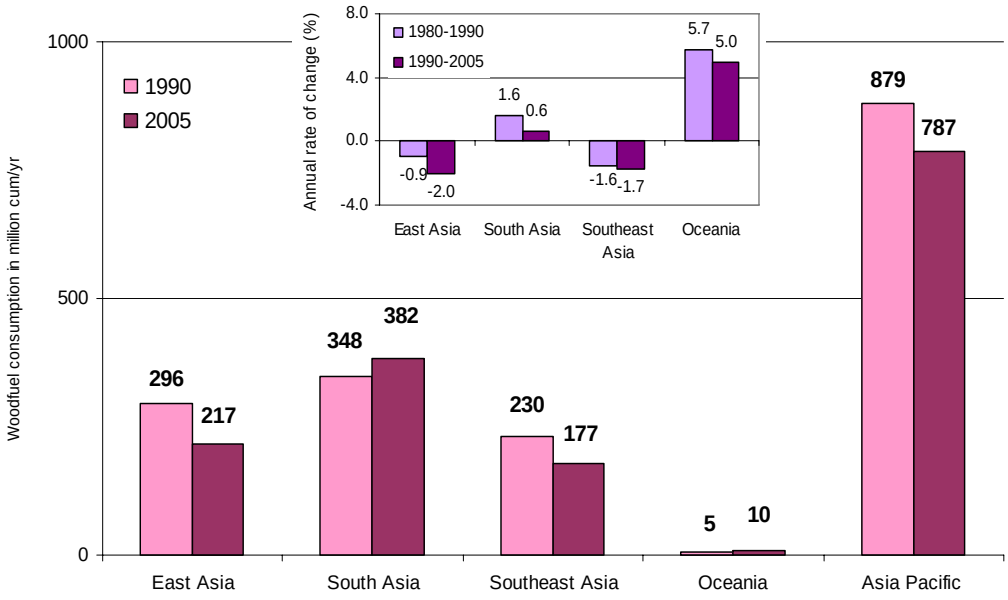


Figure 12. Woodfuel consumption in the sub-region compared to total Asia-Pacific consumption

In Pacific islands, even though the amount of consumption is small compared to the other sub-regions as shown by the small share of the total consumption in the region, the share increased twofold from 1990. This increase can be attributed to the high increase in Australia with an average annual growth rate at 6 percent, higher than the average annual rate of change in the Pacific islands as a whole (5 percent). In Australia, 2.3 percent out of 6 percent energy from renewable sources is in the form of wood and the remaining sources come from sugar residue and hydropower (2.3 and 1.3 percent respectively). The wood is used for heating in rural areas, which account for 7 percent of the total population, and an estimated 5 million

Box 3. Impact of Firewood in Australia

Based on a study conducted by CSIRO, Australian households burned between 4.5 and 5.5 million tonnes of firewood in 12 months. When industrial firewood use is included, the total amount was higher, around 6-7 million tonnes. Approximately half of the firewood burned in households is collected by the residents and around three-quarters of the people who collect their own firewood not only gather fallen timber but also take live and standing dead timber.

The four most commonly burned tree species, in order of popularity, are river red gum (*Eucalyptus camaldulensis*, 1.1 million tonnes), jarrah (*E. marginata*, 0.61 million tonnes), red box and yellow box (*E. polyanthemos, E. melliodora*, 0.54 million tonnes) and ironbark (*E. sideroxylon*, 0.47 million tonnes).

Inland forests and woodlands in lower rainfall zones appear to be the ecological communities most threatened by firewood collection, as they comprise popular firewood species, have been most extensively cleared for agriculture and have a very slow growth rate. Up to 80 percent of fallen timber may have been removed from red gum forests. Roadside and other public land has been badly degraded by firewood collection and up to 80 percent of green timber has been removed.

Most firewood is purchased from small suppliers (60 percent), who represent a completely unregulated market that is worth about US$260 million/year.

tonnes (18% of total timber removal) is taken from forest and woodlands for firewood each year, while other uses mainly involve co-generation where wood is used to generate energy in the wood processing facility (IFA, 2002). Annual fuel demand varies widely, ranging from 3-5 oven dry tonnes (odt) for domestic heating to 1,500-2,000 odt for small electricity generating plants used by small industries (Stucley et al., 2004).

Trends of woodfuel consumption towards 2020

Globally, woodfuel consumption will show increasing trends towards 2020, and reach about 2 billion m^3. However the Asia-Pacific region shows the opposite; woodfuel consumption in this region shows a declining trend towards 2020 as presented in Table 5 and Figure 13. Although the world shows an increasing consumption trend, its annual growth rate declines gradually. Charcoal shows an increasing trend in absolute amounts for both the world in general and in the Asia-Pacific region (Table 5).

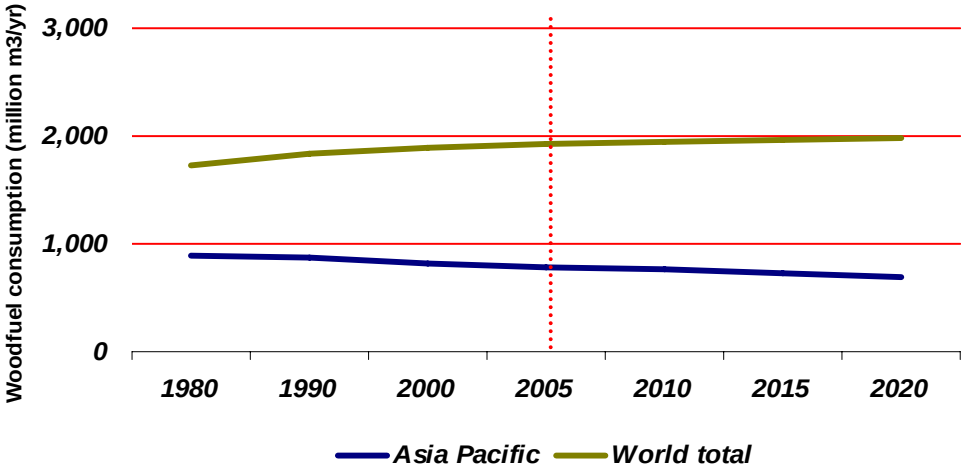


Figure 13. Trends in woodfuel consumption in the world and the Asia Pacific region

The high level of the decline is mostly attributed to the high decline in consumption in East Asia and Southeast Asia with an average rate of annual change at 1.6 and 1.7 percent respectively (Figure 14). Indonesia, China, and Malaysia are the main contributors to this decline, while Indonesia has the highest level among others (2.8 percent). This is probably caused by an increase in economic growth as shown by the increase in GDP per capita, increase in population and increase in the percentage of urban population. Increased income and urbanization will reduce demand for fuelwood and in turn will lead to greater access to alternative energy sources (for example charcoal). For East Asia and Southeast Asia, woodfuel trends show a declining trend, while charcoal shows the opposite as presented in Figure 15.

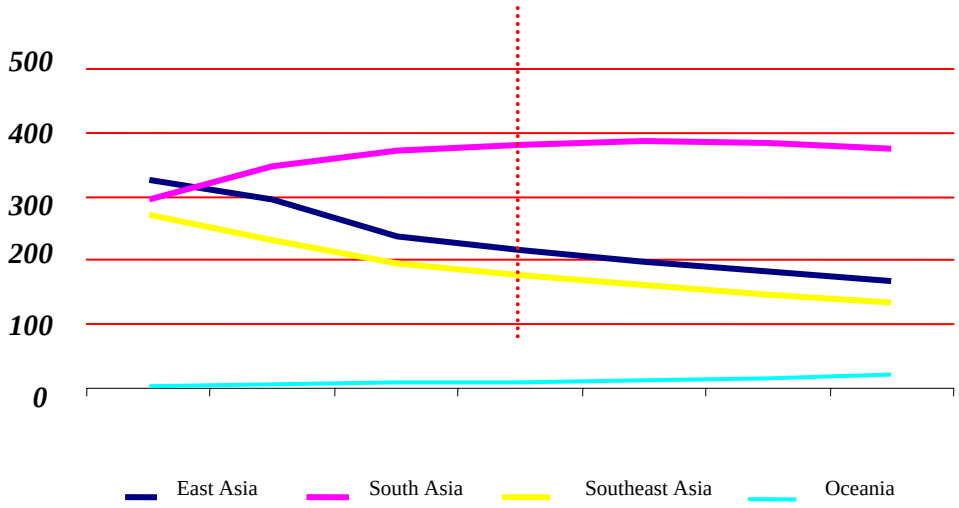


Figure 14. Woodfuel consumption (million m^3/yr)

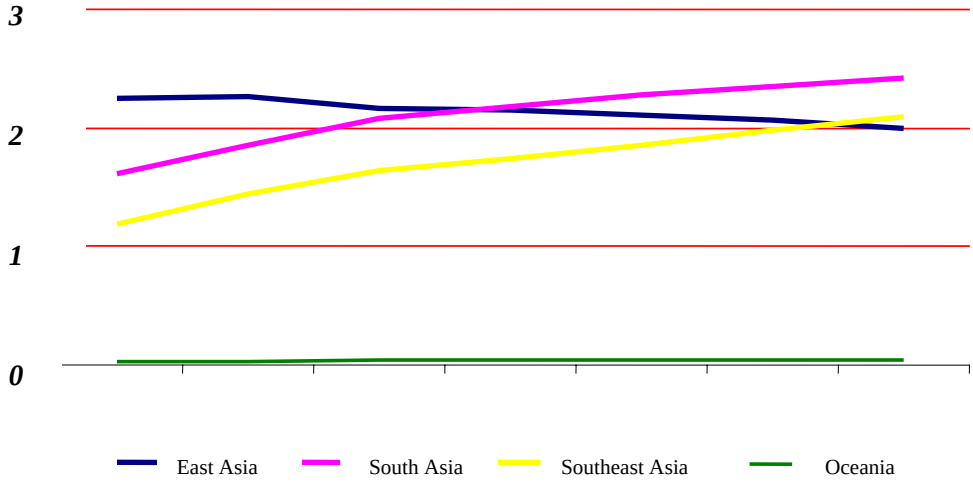


Figure 15. Charcoal consumption amongst the sub-regions

Table 5. Trends of woodfuel consumption in the Asia-Pacific region, 1980-2020

	1980	1990	2000	2005	2010	2015	2020
Fuelwood (million m^3/yr)							
East Asia	311	283	224	204	186	170	155
South Asia	287	336	360	369	372	369	362
Southeast Asia	263	222	184	167	150	136	122
Pacific	3	5	8	10	13	16	20
Asia Pacific	864	845	776	750	721	691	659
World	1,573	1,612	1,622	1,613	1,602	1,591	1,573
Charcoal (million t/yr)							
East Asia	2.3	2.3	2.2	2.1	2.1	2.1	2.0
South Asia	1.6	1.9	2.1	2.2	2.3	2.3	2.4
Southeast Asia	1.2	1.4	1.6	1.7	1.9	2.0	2.1
Pacific	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Asia Pacific	5.1	5.6	5.9	6.1	6.3	6.4	6.6
World	27.0	35.8	45.8	50.7	55.8	61.2	66.3
Woodfuel (million m^3/yr)							
East Asia	325	296	237	217	199	183	167
South Asia	296	348	372	382	386	383	376
Southeast Asia	270	230	194	177	161	148	135
Pacific	3	5	8	10	13	16	20
Asia Pacific	894	879	811	787	759	730	699
World	1,736	1,829	1,899	1,920	1,941	1,961	1,975

Source: FAO (2003)

If we compare the share of traditional biomass energy (refer to CER) to total primary energy consumption, based on data from the IAE from 1980-2005 (OECD/IEA 2007), it clearly shows that the share of traditional biomass energy has been gradually declining, as presented in Figure 16. The share of this energy source declined for almost half of the share since 1980, from 27 percent down to 16 percent in 2005. Oil consumption is also in a declining trend, while coal and gas are increasing, and in particular gas has shown a high rise, more than twofold as compared to the 1980 share.

If we look at per capita consumption, the trend gives a similar picture, as presented in Figure 17. For the past two decades, the Asia-Pacific region has witnessed a declining trend in per capita consumption, and this pattern will remain for the two decades to come. This trend is in line with the world situation, even with a different rate of change where Asia and the Pacific exceeded the declining rate. Figure 18 shows a similar pattern in the sub-region as woodfuel consumption per capita declined in almost all sub-regions with annual rates of change varying amongst the sub-regions.

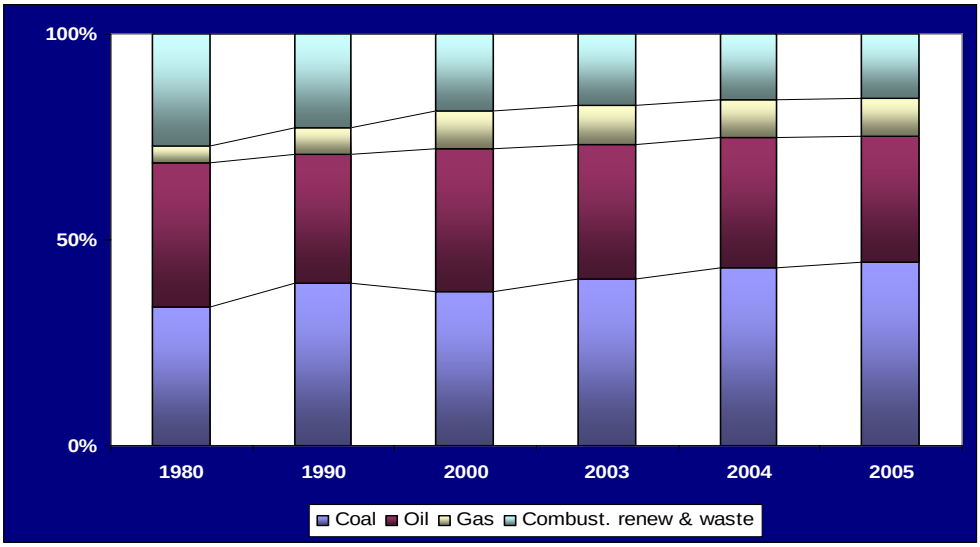


Figure 16. Trends of combustible renewable energy from 1980-2005 in the Asia Pacific region

Source: OECD/IEA (2007)[4]

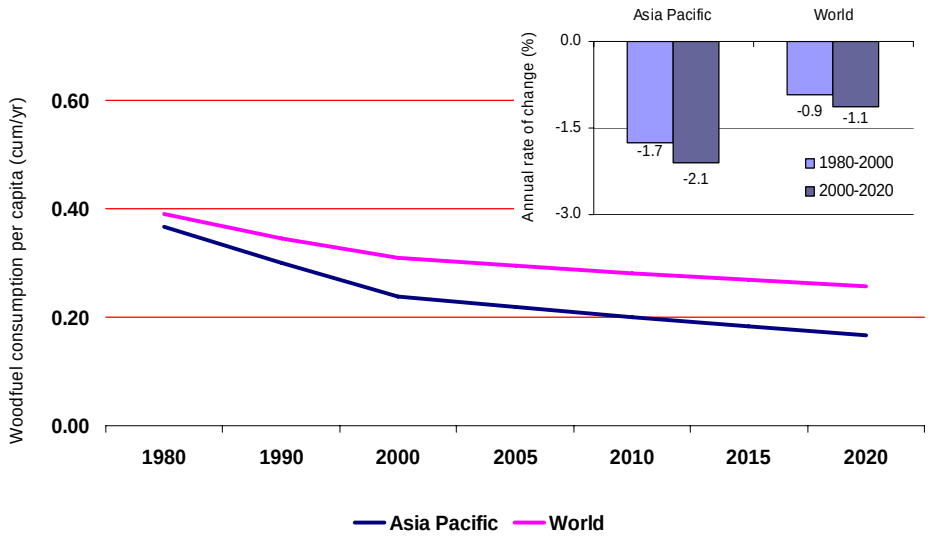


Figure 17. Woodfuel consumption per capita in the Asia-Pacific region compared to the world

Source: FAO (2003)

[4] Note: Asia Pacific in this graph is an aggregation of Asia, China and OECD Pacific. Asia includes Bangladesh, Brunei, Cambodia, Chinese Taipei, India, Indonesia, DPRK, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam and Other Asia and Other Oceania (includes Afghanistan, Bhutan, Fiji, French Polynesia, Kiribati, Lao PDR, Macau, Maldives, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu), China includes China and Hong Kong and OECD Pacific includes Australia and New Zealand.

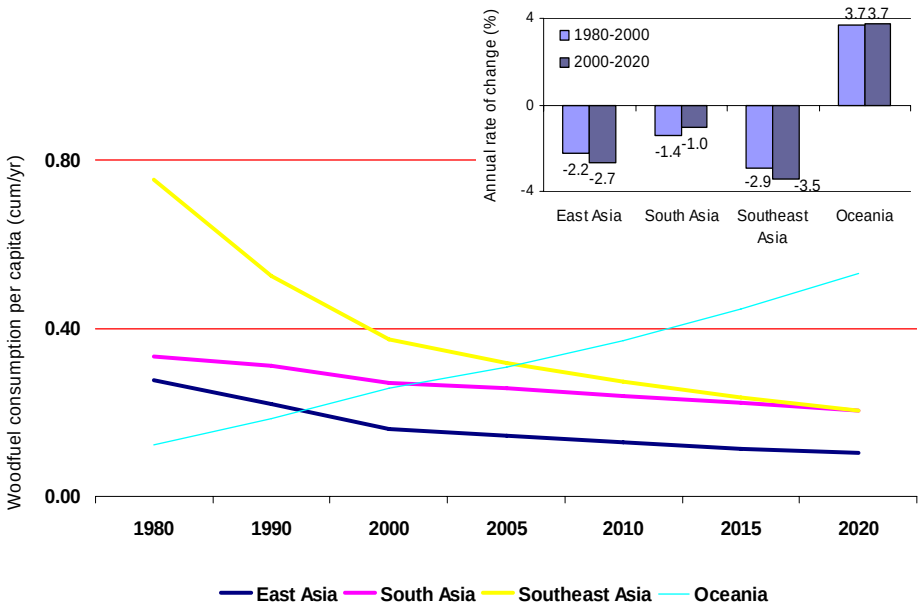


Figure 18. Woodfuel consumption per capita amongst the sub-regions

Source: FAO (2003).

However, the Pacific islands showed an increased level of consumption per capita with an average annual rate at about 4 percent in the last two decades that will remain for the coming two decades. The increased consumption per capita pattern in the Pacific islands was triggered by the increased consumption in Australia and Fiji. Some of the countries show a declining trend for the next two decades, such as New Zealand, Papua New Guinea, Solomon Islands and Vanuatu, while for New Caledonia, Cook Islands, Kiribati, Samoa and Tonga, the share of their consumption is the smallest (0.02-0.05 m^3/yr). This is partly because of highly urbanized populations where alternative energy is available or because resources are unavailable. For example in Kiribati and Tonga, the population is predominantly rural, but since they do not have available resources, with less than 10 percent of forest and other woodland area, their woodfuel consumption per capita is very small (almost insignificant) (Figure 19).

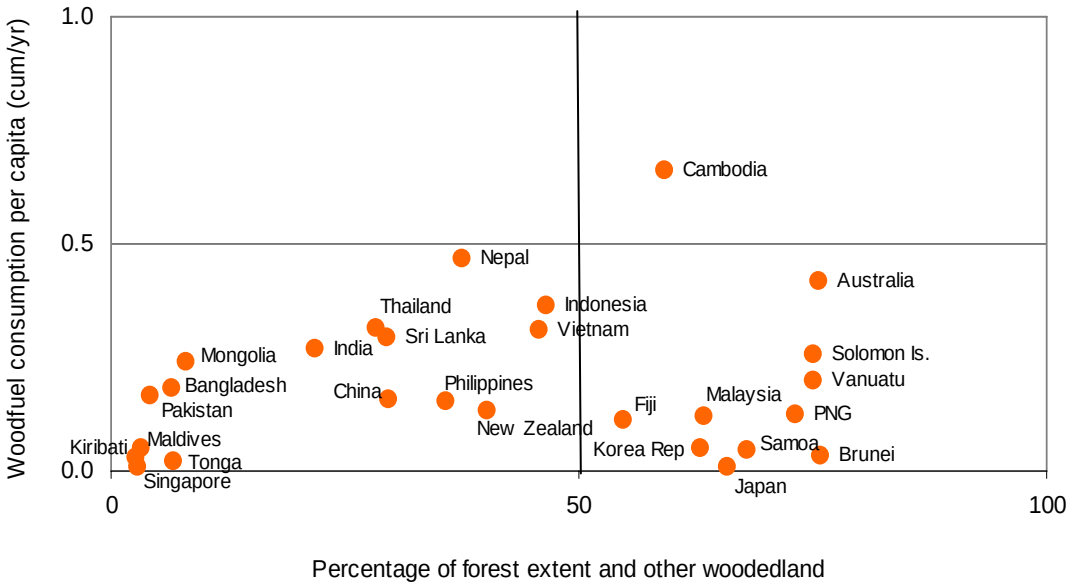


Figure 19. Relationship between percentage of forest extent and other wooded land with woodfuel consumption per capita in 2005

Source: FAO (2003; 2005)

Consumption pattern of biomass energy

Household consumption pattern

The most significant changes in woodfuel consumption are at the household level, where many households are shifting from traditional to more convenient energy sources (electricity/kerosene/LPG) in response to their increased level of income. As income increases, the preference of energy sources changes and shifts towards more convenient energy sources. Increased income at the household level will lead to increased standards of living and changes in lifestyle that will affect household decisions on energy consumption; there will be a tendency to move from the cheapest and least convenient energy sources (biomass) to more convenient and expensive (for example charcoal and kerosene) source and finally to a more modern and most expensive (for example LPG, natural gas and electricity) source (Box 4).

At low income level, households are more likely to collect woodfuel than to buy alternative sources from the market. But the presence of the market may likely reduce woodfuel consumption due to an increase in opportunity cost at collection time. Thus access to an available market can also be a main factor influencing the household decision on woodfuel consumption. However, it is also important to note that increased income does not imply that the household will make an entire shift replacing an existing form of energy, but rather use an alternative energy source on a supplementary basis. Generally, climbing up the ladder tends to occur gradually as most households use a combination of energy sources that can be categorized as traditional such as fuelwood, agricultural residues and dung; intermediate such as charcoal and kerosene; and modern such as LPG, biogas and electricity. Use of many energy sources gives a sense of security, as households will be more prone to price variation once they rely on single energy sources or technology.

Box 4. Change Patterns in Woodfuel Consumption

Wood is the main source of fuel for open fire cooking and stone-ovens which is the traditional way of preparing food. However, modern lifestyle changes have seen the use of wood as fuel increasingly replaced by electricity and liquefied petroleum gas (LPG), and coconut shell charcoal for charcoal ovens. Local ready-to-eat foods cooked in the traditional way are readily available from roadside vendors and delis, and buying local ready-to-eat food rather than cooking at home is a recent lifestyle change. The demand for woodfuel in homes is therefore significantly reduced.

These changes in lifestyles apply generally but more particularly to the urban population of Apia. Statistics on woodfuel production and consumption are not collected and although stacks of firewood are often seen at the produce market in Apia and on roadsides around the urban areas, it is estimated that the demand has been declining over the last 10 years, and is probably leveling off.

Changing pattern in consumption is also determined by resource availability and accessibility. Access to woodfuel affects the level of consumption as it can force users to shift to alternative source of energy when there is a limitation imposed by the location of the resources or land tenure issues. Limitation in resource availability can force users also to use alternative energy and shift to commercial energy source, especially when the supply is also readily available.

In China the share of woodfuel consumption is smaller, where a large proportion of households use coal instead (OECD/IEA 2006). For example in Northern and Southern China where woodfuel is not readily available, coal has become a major source of energy. Purchased coal is used extensively as a fuel in the majority of rural communities in this area. In this case increased income did not have a significant impact on woodfuel consumption. Another example that can illustrate the impact of limitation on resource availability is from the share of forest area, for example in China and Bangladesh (where the share of forest area is less than 25 percent), while in highly forested countries where the share of forest area is more than 60 percent, wood is dominant, such as in Cambodia, Lao PDR and Bhutan.

Cooking and heating are the most energy consuming activities in most rural an urban poor households in developing countries where biomass energy is the most important energy source, and these two activities are the last to switch. This can be due to the unwillingness of the households to use other than traditional energy in order to retain the taste preference and some reluctance to use modern technology and feel more familiar with traditional technology; for example in India and Philippines (and also in any other countries) many households still keep their traditional wood stoves for cooking traditional dishes. As income increases and the fuel option is widened, the fuel mix may change, but wood is rarely entirely excluded (OECD/IEA 2006) (Box 5).

- **Box 5. Bio-energy in the Overall Philippine Energy Mix**

The main fuel used for cooking in the Philippines includes agricultural residues, fuelwood, charcoal, liquefied petroleum gas (LPG) and kerosene. Woodfuel continues to be an important source of energy in the Philippines and the use of multiple fuels has a long tradition, where woodfuel is used either as primary or secondary fuel at the household level. A case study in Cebu described this pattern. Fuel-switching from woodfuel toward liquefied petroleum gas (LPG) and kerosene happened in many households. But in spite of rapid urbanization, many households continued to depend on woodfuel and biomass residues for various reasons. The decision on choosing fuel in Cebu is driven by various factors, including income, price, availability and ease of purchasing, fuel quality, taste and preference. Among others, woodfuel is perceived to be more economical compared to commercial fuels, food cooked in wood stoves gives better taste and woodfuel is believed to be a good back-up for LPG. LPG and electricity are chosen because they are clean, convenient and time saving, while charcoal is preferred as it is cleaner than fuelwood and best for barbequed and roasted food.

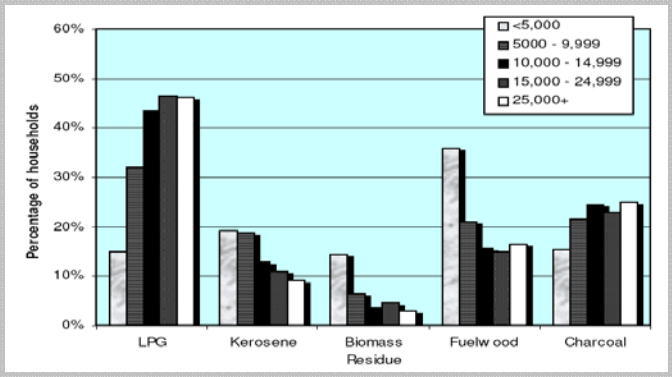


Figure 20. Percentage of urban households using cooking fuels by monthly income in 1995

Major driving forces affecting the use of biomass energy

Demographic changes: population growth and urbanization

Population growth and urbanization are important factors affecting the changing pattern in woodfuel consumption. There is a strong relationship between the two variables, where increase in population and urbanization will increase woodfuel consumption. Those factors can be used to see the changes in woodfuel consumption patterns and together with economic development will increase household income, which in turn will lead to major changes in the household energy consumption (Girard, 2002). Urbanization will lead to greater access to alternative energy sources and reduce access to forest resource (RWEDP, 1997; Whiteman et al., 2002).

The five most populous countries in the Asia-Pacific region were China, India, Indonesia, Japan and Bangladesh until Pakistan overtook Japan in 2000; this will remain towards 2020. In the last decades population growth in this region has increased gradually, as indicated by the increase shared of this region to the total world population from 54.9 percent in 1980 to 55.5 percent in 2000. The rapid growth in population has resulted in increased urbanization. In general, urban population in the Asia-Pacific region increased at an average annual rate of 2.98 percent in the period 2000-2005. Southeast Asia was urbanizing more rapidly than other regions with an average annual rate of 3.88 percent, followed by East Asia (2.83 percent) and South Asia (2.81 percent), while the Pacific islands had the smallest annual growth rate (1.63 percent) for the same period, as almost three-quarters of the Pacific islands resides in urban areas which makes this sub-region the most urbanized sub-region in Asia and the Pacific.

A shift will occur from traditional to commercial energy sources and in turn this will lead to higher levels of household consumption of commercial energy sources and a decrease in consumption per capita. Some factors that contribute to this trend, among others, are decline in resource accessibility and improvement of the availability of commercial energy sources in urban areas. The more developed the countries, the more areas becoming urbanized and more people live in the cities. For this segment of society, access to woodfuel sources becomes limited but access to commercial fuels will become greater. Figure 21 shows that countries with a high percentage of urban population consume less woodfuel (for example Hong Kong, Singapore, Brunei, Japan, etc.) than those in predominantly rural countries (for example Cambodia, Nepal).

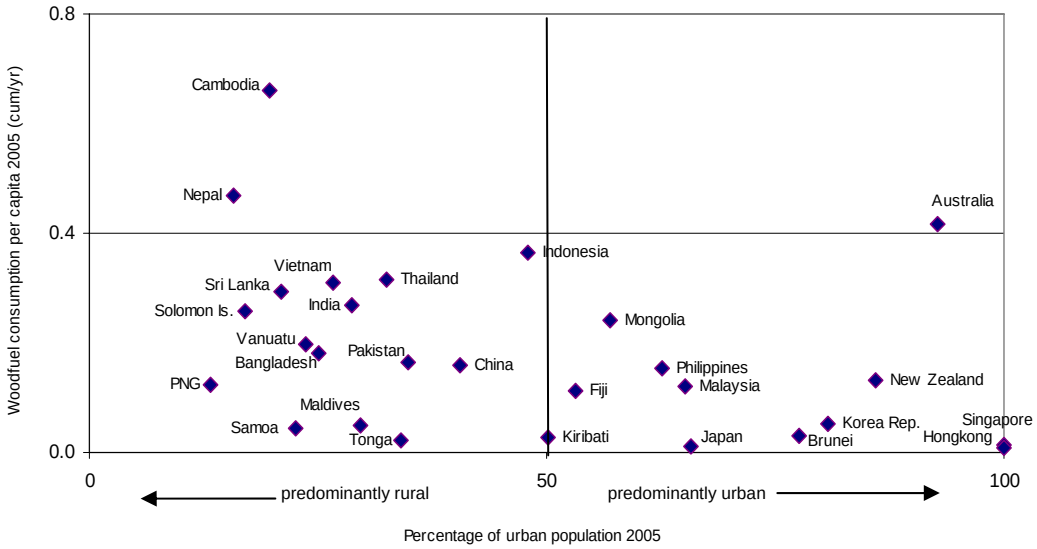


Figure 21. Relationship between woodfuel consumption and urbanization

Source: FAO (2003); UN Common Database (2007).

However, increased commercial energy sources will not replace completely the use of traditional biomass energy, as for many rural communities this source of energy is the only affordable source due to limited income, underemployment and no ready cash available to purchase commercial substitutes. For example in the case of Southeast Asia, woodfuel consumption has decreased as a result of population growth and urbanization; on the other hand this is not the case for South Asia where woodfuel consumption is still high regardless of the high rate of population and urbanization growth (Figure 22). Furthermore, although urbanization is associated with lower dependency on traditional biomass energy, the use of other commercial energy sources, such as LPG is not always widespread in towns or cities.

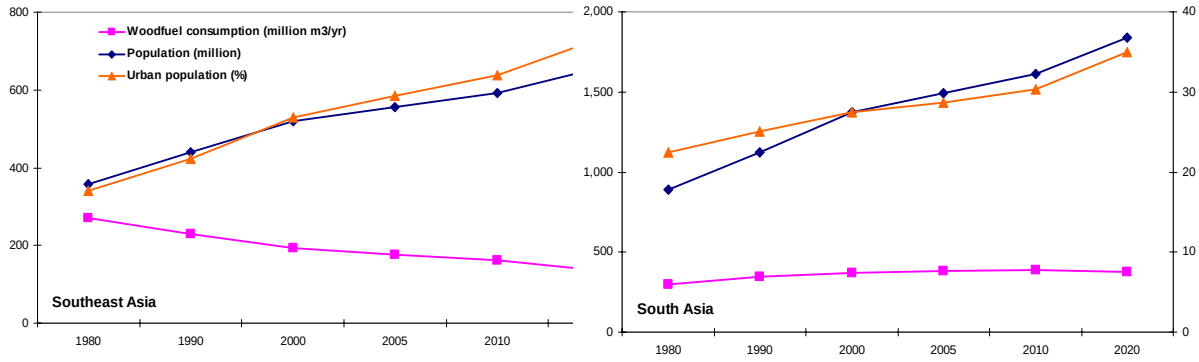


Figure 22. Relationship between woodfuel consumption, population and percentage of urban population

Source: FAO (2003); UN Common Database (2007)

Increased income

Increased income level is a key determinant factor to the change in consumption patterns, in terms of quantity and type of energy source purchased. There is a strong positive correlation between per capita income and household demand for commercial energy. In general increase in per capita income will lead to an increase in household demand for commercial energy sources that in turn will decrease household consumption on traditional energy sources. To describe this pattern, various countries in this region are presented in Figure 23. It is clearly shown that countries with low GDP per capita (less than US$500) have very high reliance on woodfuel as in the case of Bangladesh, Cambodia and Nepal, and countries with high GDP per capita have less dependence (almost insignificant) on woodfuel, as in the case of Brunei, Hong Kong, Republic of Korea, New Zealand and Singapore. A study by Victor and Victor (2002), using the relationship between the share of fuelwood in total energy consumption and rise of income in several Asian countries showed the same pattern, confirming strong relationship between the two variables; as income increases the fuelwood share in total household energy consumption will decline (Figure 24).

Consumption pattern differs according to location (urban or rural), level of income, household size and availability of alternative energy. Yet increasing income level and urbanization are the major driving factors affecting the woodfuel consumption pattern and consumption transition, as most people who switch their consumption pattern are located in urban areas, with better supply of alternative energy sources.

Environmental concerns

Increase in economic activity and population have always been followed by increase in energy consumption. Meeting energy needs will have a significant cost and impact on global climate change, as increased use of fossil fuels for residential, industrial and transportation needs will increase greenhouse gas (GHG) emissions. Especially in developing countries, energy demand and economic growth are highly correlated and energy-related carbon emissions are affected by economic growth (Choi and Ang, 2001; Baumert et al., 2005).

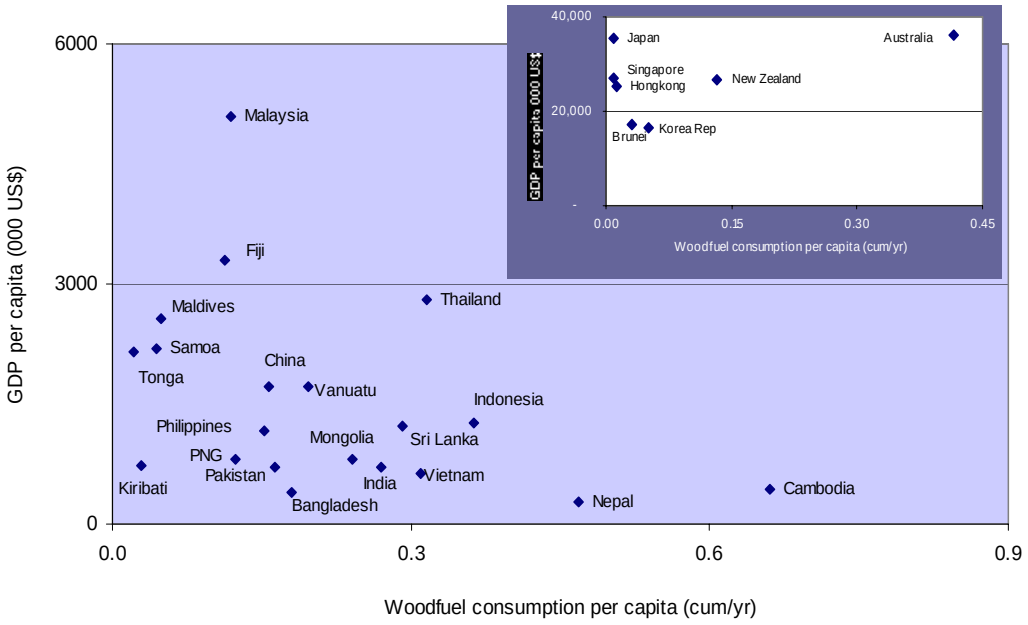


Figure 23. Woodfuel consumption per capita and GDP per capita in 2005
Source: FAO (2003); WB (2006)

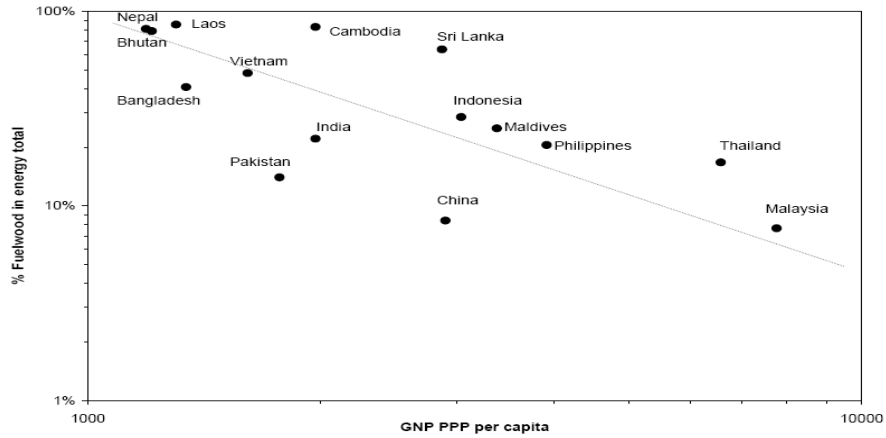


Figure 24. Relationship between share of fuelwood consumption and GNP (PPP) per capita (Victor and Victor, 2002, data source from UN and WB)

Fossil fuels remain the dominant energy and account for more than two-thirds of the GHG emissions addressed by the Kyoto Protocol. Globally growth of carbon dioxide (CO_2) emissions from energy use was 1.9 percent per year between 1971 and 1998, where developed countries were responsible for over 50 percent of CO_2 emissions. Developing countries in the Asia-Pacific region emitted 22 percent of the global total CO_2, with increases of about 4.9 percent annually since 1990 (IPCC, 2001). Amongst countries in this region, China, India and Japan are in the top ten rank of CO_2 emitting countries. China is the second largest emitting country, after the United States (21 percent), with a 15 percent share of CO_2 emissions, followed by India (6 percent) and Japan (4 percent) (Baumert et al., 2005). r

Biomass is considered as a carbon dioxide neutral fuel, as it produces zero net CO_2 emission. Current global concern on climate change, as well as energy security, has opened up new opportunity for biomass-based energy uses. Biomass can play a vital role in reducing GHG emissions, help countries to reduce the reliance on imported fossil fuels, which will create diversification of energy mix, and contribute significantly to meeting global energy demand. Biomass utilization can also be used as part of an effort for developed countries to comply with the Kyoto Protocol, as under this international treaty they are bounded to reduce their GHG emissions by an average of 5 percent during the first commitment period (2008-2012).

Box 6. Trends in Energy and GHG Emission

- High use of low-quality traditional fuels in rural areas
- 80 percent of energy generation from fossil fuels
- Last quarter of 20th century saw huge rise in energy consumption
- Industrial use of fossil fuels is growing 60 percent faster than anywhere else
- CO_2 emissions are rising due to heavy use of poor quality coal, extensive forest fires and land clearing
- Per capita emissions are only slightly over 50 percent of the world average
- China and India are currently largest emitters in the region

UNED Forum (2002).

Pollution and health issues

Globally, half of the population lives in rural areas of which around two-third reside in the Asia-Pacific region, where the majority of the population relies heavily on this energy source for household uses, cooking and space heating. Reliance on traditional biomass energy (including wood, charcoal, dung, agricultural residues and coal) has posed severe threats to health. Traditional biomass energy is often burned in open fires or is used in poor and inefficient technology which results in incomplete combustion and produces pollutant emissions, primarily carbon monoxide, but also polyaromatic hydrocarbons, formaldehyde and many other compounds posing health hazards. Different types of fuels release different amounts of emissions (Box 7). Burning traditional biomass energy exposes households to indoor air pollution and causes many different diseases, including acute and chronic respiratory diseases, tuberculosis, asthma, cardiovascular disease and perinatal health outcomes. A recent review revealed there is strong evidence that the health effect of indoor air pollution has grown in the past ten years and there is reasonably good evidence that exposure increases the risk of acute lower respiratory infections (ALRI) among children under five years of age, and chronic obstructive pulmonary disease (COPD) in adults and lung cancer where coal is used extensively (WHO, 2000).

Box 7. Emission of Major Toxic Pollutants in India

Figure 25 shows pollutant emissions per meal in typical cookstoves in India, relative to LPG (1.0 on the scale) as the most common clean fuel available. It is clearly shown that there is a strong correlation between emission level and the types of fuel use (which can also illustrate clean, efficient and convenient energy uses). Traditional biomass energy is a major toxic pollutant compared to other commercial energy types.

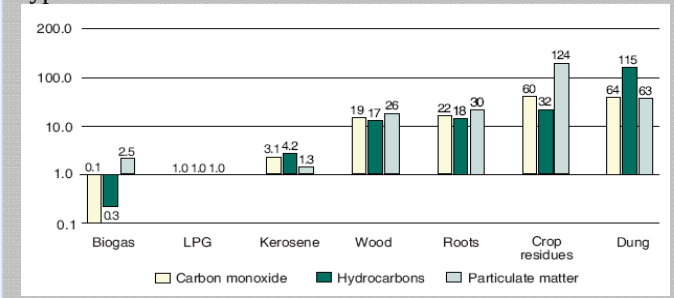


Figure 25. Pollutant emissions/meal in cookstoves in India
Source: Smith et al., 2005 (in Smith, 2006)

There is much evidence that indoor air pollution affects mostly women and children, who spend most time in domestic activity, such as cooking. In 2000, indoor air pollution was

responsible for more than 1.5 million deaths annually in developing countries and around 2.7 percent of the burden of disease (BOD) globally, and the percentage is higher in developing countries, accounting for 3.7 percent of the BOD (WHO, 2007). In the Asia-Pacific region, the average percentage of BOD due to indoor air pollution from traditional biomass energy use is 1.3 percent; the high rank of the BOD percentage is attributed to Bangladesh, India, Lao PDR, Myanmar, Pakistan and PNG, with percentage ranging from 3.2-4.6 (Annex 2).

Considering the severe impact of indoor air pollution on human health, in particular for poor households in developing countries, there is greater awareness of the relationship between household energy, health and poverty globally. Poverty is clearly a major hindrance for households to move up the energy ladder. There is an urgent need to improve access for the poor to more cleaner, efficient and convenient types of energy sources. The magnitude of this issue has increased international attention, by putting this issue as the main agenda at international events, for example the UN Commission for Sustainable Development (CSD-14 and CSD-15), and appealing to the international community to tackle the indoor air pollution problem (Box 8).

Box 8. 4,000 Deaths a Day from Cooking Fires? Let's Prevent Them!'

Household energy, indoor air pollution and associated health risks issues highlighted prominently in the fourteenth session of UN Commission for Sustainable Development. *'4000 deaths a day from cooking fires? Lets prevent them!'* were used as a theme for a side event in CSD-14, organized by WHO, GTZ, Practical Action and the Partnership for Clean Indoor Air (PCIA). This theme reflected the importance of, and increased international awareness about this issue.

The side event was used to draw international attention to the severe impact of using direct burning of bio-energy and coal for cooking and heating in developing countries and urged the international community to take action together to improve access for the poor to cleaner alternative energy sources. The international community agreed about the danger and the urgent need of improving access of the poor to cleaner energy sources; an international commitment was built (such as from the European Commission, in particular European Union member countries) to work and tackle these issues together.

Source: HEDON Boiling Point No 52 (2006).

4. SCENARIOS OF BIOMASS USE FOR ENERGY

Scenario definition

Scenarios are images of an alternative future. Scenarios can be used as useful tools to illustrate and understand a probable vision of the future and development pathway of energy use. Scenarios can guide us to think what situation might happen in two decades to come, considering many factors that will facilitate or hinder the pathway of the development and to see how driving forces might influence future pattern. There are two different approaches in developing scenarios, one will be qualitative analysis focusing more on descriptive analysis, best communicated by images and stories, while the other is based on quantitative analysis using modelling tools (Box 9).

Scenario setting

In this section, scenarios are developed by using qualitative and narrative approaches, while some of the actual numbers will be used for illustrative purposes to explore a range of possible futures and provide a set of alternative storylines in biomass energy consumption patterns in the region. Scenarios will be developed by assessing key driving forces and the relationships among them. For this exercise, economic growth and population dynamics are identified as the main factors that have critical influence on the changing patterns in biomass energy use and will be used as a basis for scenario development.

Environmental consideration and energy security (also unstable fossil fuel prices) also have a significant effect that will alter the changing pattern, but will not be as influential as economic growth and population dynamics (as its evolution will give direct impact within the country, especially to households as major end-users for biomass energy). Therefore, these two aspects will be used to define the scenarios and explore how this combined aspect will lead to the future direction of developments in biomass energy use, while the others will also be discussed in order to complement and support the discussion.

Box 9. Scenario Definition

The term "scenarios" appears in two distinct streams of inquiry, one based on qualitative narrative and the other on mathematical models. Qualitative scenarios are primarily literary exercises, aimed at holistic and integrated sketches of future visions and compelling accounts of a progression of events that might lead to those futures. Quantitative, formal models seek mathematical representation of key features of human and/or environmental systems in order to represent the evolution of the system under alternative assumptions, such as population, economic growth, technological change, and environmental sensitivity. Qualitative scenarios have a greater power to posit system shifts, to explore the implications of surprise, and to include critical factors that defy quantification, such as values, cultural shifts, and institutional features.

Source: Intergovernmental Panel on Climate Change (2001).

Scenarios are plausible, challenging, and relevant stories about how the future might unfold, which can be told in both words and numbers. Scenarios are not forecasts, projections, predictions, or recommendations. They are about envisioning future pathways and accounting for critical uncertainties.

Source: Millennium Ecosystem Assessment (2005)

Energy is a vital element, as many views say it is "fuel for growth", to support socio-economic development, ranging from the industrial, transportation as well as residential sectors. Energy use patterns largely depend on economic growth, demographic change and relative cost of availability of different energy sources. Population growth, rate of urbanization and increased prosperity are the main driving forces that lead to the changing pattern of energy use. In addition, environmental awareness and energy security have also become important elements that will drive the changing pattern. Energy security is related to the supply side, in particular oil and gas. Rising demand and resource depletion will have an adverse impact on economic development as well as the political situation (as the major exporting countries are situated in unstable regions, e.g. the Middle East) and social instabilities (for example rising and fluctuating prices) in many countries. The last two driving forces have triggered the growing interest in biomass energy in this past decade and this will impact energy consumption dynamics in the future.

The Asia-Pacific region is among the fastest-growing regions in the world, in terms of both population and economic growth. More than half of the world population resides in this region and although population growth rate is on the declining trend towards 2020, but in absolute terms, it is projected to increase about two-thirds, from 2.4 billion in 1980 to 4.2 billion in 2020. China, India Indonesia, Pakistan and Bangladesh are the major contributors to the increment. The Asia-Pacific region has attained high economic growth, Asian countries accounted for 5.3 percent per annum for this last 15 years (1990-2005[5]), and for several developing countries the growth has been truly impressive, for example India and China with annual economic growth of about 6 and 10.1 percent respectively, higher than average annual growth in the world (3.4 percent) and developed countries (2.5 percent) for the same period. Increased income is always followed by increase in standard of living that in turn will draw people to move to more urbanized places. High rate of urbanization is mainly attributed to the countries with high population. In general the Asia-Pacific region is in an accelerating stage of urbanization, with Southeast Asia having the highest growth rate, followed by East Asia and South Asia. However, considering the overall situation will vary amongst countries with various levels of economic performance and demographic changes, hence for the purpose of exploring the scenarios, countries will be clustered into three groups, as described in Table 6.

Table 6. Country clusters and their characteristics

Clusters	Characteristics	Countries
Small Islands	Low-middle income, low population (less than one million), low-high rate of urbanization	Cook Islands, Fiji, Kiribati, Maldives, New Caledonia, Samoa, Solomon Islands, Tonga, Vanuatu
Developing Economies	Low-middle income with rapid economic growth, proportion of rural population is still high but with high rate of urbanization	Bangladesh, Bhutan, Brunei Cambodia, China, DPR Korea, India, Indonesia, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, PNG, Sri Lanka, Thailand and Vietnam
Industrialized (Advanced Industrialized Economies and Newly Industrialized Economies)	High income, high proportion of urban population, low growth rate of urbanization	Australia (AIE), Hong Kong (NIE), Japan (AIE), Korea Rep. (NIE), New Zealand (AIE), Singapore (NIE)

[5] Source: OECD/IEA (2007). GDP using Purchasing Power Parities (in billion 2000 US$).

Scenarios

It is well-acknowledged that woodfuel is not only used by developing countries, but also by developed countries. The difference between the two user groups is that the first group, representing the majority of woodfuel consumers (about 2.2 billion people who live in rural areas), uses inefficient, highly polluting fuel sources and still operates informally. While the second group typically uses highly-efficient combustion technology under tight regulations on emissions that is traded commercially.

For most of the industrialized countries environmental value is stronger, biomass energy is valued as a means of reducing greenhouse gas emissions to meet clean air policies. And in addition the increased role of biomass energy becomes important in these countries to increase energy supply security and decrease heavy reliance on conventional and imported fuels. On the one hand, with high GDP per capita and high standard of living, these countries have enjoyed easy access to modern energy services, but on the other hand, since most of these countries are major importers of fossil fuels, energy supply security and energy emissions become a challenge.

Box 10. Reshaping Our Energy Future

By 2050, global carbon emissions would need to be at levels similar to 2000, but also trending downward, in contrast to a sharply rising demand for energy over the same period. No single solution will deliver this change, rather we need a mix of options which focus on using energy more efficiently and lowering its carbon intensity. Changes in supply and demand can help us shift to a truly sustainable energy path. While change takes time, starting the process now and laying foundations for the future are matters of urgency, and business has a key role to play.

Source: WBCSD (2004)

One of the ways to handle these issues is diversifying the energy mix through the use of indigenous energy resources, as most of these countries have various types of renewable energy resources that can enable them to reduce their dependency of fossil fuels and reduce GHG emissions. However within these countries, investment in renewable energy technology has not yet led significantly to biomass energy, but mostly goes to modern renewable energy, such as hydro, solar and wind power. For example Korean government plans to increase the share of renewable energy to 5 percent in total energy consumption by 2011, from 1.4 percent as of 2002, and concentrate mostly on hydro fuel cell, photovoltaic and wind power, as it is considered having viable market potential. While New Zealand focuses mainly on hydro and geothermal and Hong Kong on solar and wind power, Australia has set policy measures, the Mandatory Renewable Energy Target (MRET), that requires the generation of 9,500 GWh of renewable electricity per year by 2010 and maintained until 2020 (APERC, 2004).

Concern of greenhouse gas emissions creates international agreements and programmes, for example Australia, China, Japan, Republic of Korea, India and the United States have formed the Asia Pacific Partnership of Clean Development and Climate (APCDC). The partnership offers an opportunity to set up new programmes of collaborative research and development in technologies which produce greater efficiency in combustion of fossil fuels, expand the capacities of existing technologies, undertake basic research in new energy technologies and support the capture and sequestration of carbon dioxide (Oxley, 2005).

Box 11. Wood – Largely Traditional but not Phasing Out!

In the Philippines, woodfuel remains the traditional and principal source of household energy. In 1977, the National Household Energy Survey reported that the national woodfuel consumption of the country was about 48 percent of the total consumption. The 1989 Household Energy and Consumption Survey (HECS) revealed that 67 percent of the households still used woodfuel for their energy requirements (DAP, 1992). In 1995, the HECS reported that woodfuel ranked first among the different fuels households used.

In India, wood was meeting 59.2 percent of total fuel needs in rural areas and 35.5 percent in urban areas in 1991–92. The main non-commercial energy sources combined – woodfuel, dung and agricultural residues – met 95 percent of fuel needs in rural areas. Of these, dung and agricultural wastes are widespread as fuels in agriculturally prosperous regions with fertile soils and controlled irrigation, such as Punjab, Haryana, UP and north Bihar, but wood continues to be the main domestic fuel in less endowed and poorer regions.

Source: Rebugio et al. (2000); Saxena (1997)

The future situation for developing countries will be rather a mix, between the persistence of heavy reliance on traditional biomass energy for some segments of society, and also moving towards to more modern forms of biomass energy on the other. Based on the future scenario from the previous study that *rural people have been the main users of woodfuel in the past and they will remain so in the future. Many urban poor will also continue to depend heavily on woodfuels, although there will likely be a greater shift to charcoal use compared with present consumption patterns* (FAO, 1998), traditional biomass energy will not phase out yet. Despite the slowing down of woodfuel consumption in most of the countries in the region, decreasing consumption in the case of fuelwood, while increasing consumption in the case of charcoal due to increased income and urbanization, the previous scenario seems to continue that woodfuel will remain a prominent source of energy in the coming two decades, particularly in rural areas.

Increased income will gradually change demand for modern and better energy services. However, the transition from traditional energy use to full dependence on modern energy source is not a drastic change. The three determining factors that affect the transition from traditional to modern energy use are availability, affordability and cultural preferences. If a modern distribution system is not in place, people cannot access the sources, even though they can afford them, for example LPG distribution is still low in many developing countries, partly because of lack of infrastructure distribution (IEA, 2002). Nevertheless, effort has been made to improve access to modern energy services for the poor, with higher efficiency and health advantages, for example improved stoves, rural electrification programmes, PV etc. Modernizing biomass energy use for poorer populations is an important element of sustainable development schemes in many countries (IEA, 2007).

In many developing countries, particularly rural areas, affordability is one of the main factors that will hamper the switch to modern energy sources. Households often perceive traditional energy is “free” and readily available, the cost involved is merely time spent for collecting the resources. Therefore, if the cost involved in acquiring modern energy source is high, that may discourage many households to switch from traditional energy sources. For example, for some countries like Bangladesh, Pakistan, India, Nepal, Vietnam and Cambodia with low GDP per capita and limited resources (as in the case of Bangladesh and Pakistan), traditional energy sources will likely still remain their chief energy sources. However, Cambodia and Vietnam are considered vulnerable and in a critical condition, with over 40 percent of the entire population facing critical woodfuel deficit, while Myanmar is considered less critical with 28 percent of the whole population (FAO, 2007b). Figure 26 presents the scenarios of rural population distribution in woodfuel deficit areas for various countries in Southeast Asia,

projected for 2015 using two alternative scenarios, business as usual (BAU) and the FAO Global Forest Product Outlook Study (GFPOS). According to the first scenario, around 59 million of the rural population in this sub-region will live in woodfuel deficit areas, and about 56.8 million of the rural population using the second scenario (FAO, 2007b). This is important evidence of the difficult situation that will face several countries in this sub-region.

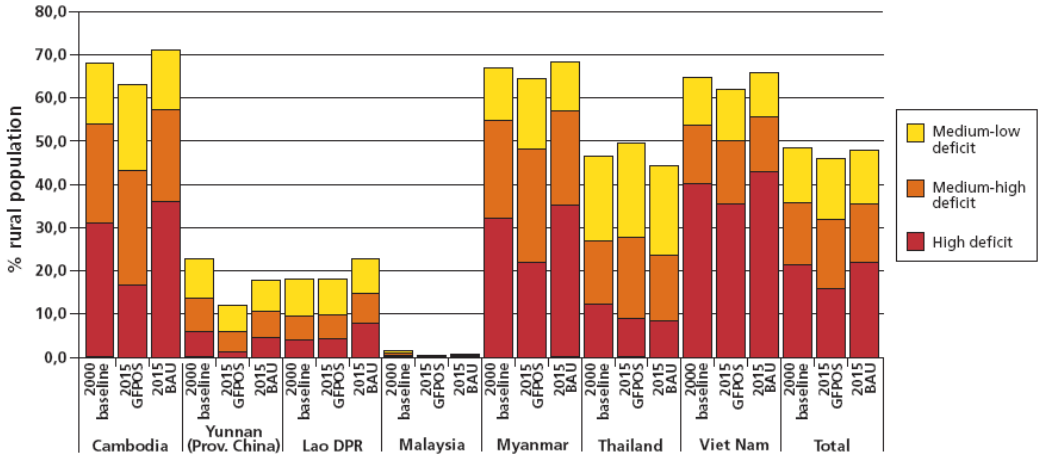


Figure 26. Distribution of rural population by deficit woodfuel supply/demand balance categories in 2000 and 2015 (FAO, 2007b)

Countries under the small islands category, mainly developing countries in the Pacific Islands (except the Maldives), are facing a unique situation in energy consumption. The population is small (less than one million), isolated, dispersed and is dominated by coastal communities. The population is predominantly rural, except in New Caledonia and Cook Islands where the urban population accounted for more than 60 percent in 2005. Most of the countries are facing rapid urbanization with average growth rate of about 3 percent per annum in the period 2000-2005.

In these countries energy resources are largely based on solar power, while some countries include hydro and biomass energy. Traditional biomass energy is not an important energy source for most of these countries although in some countries biomass from agriculture is still in use (for example bagasse is used as fuel for sugar mills in Fiji). This is most likely caused by resource limitations that in turn have made these countries rely heavily on fossil fuels, mostly oil, accounting for about 15-25 percent of total imports or more than 40 percent of the gross domestic commodity exports (CROP, 2000), largely used for commercial energy needs, e.g. transportation and electricity generation. Woodfuel consumption per capita in these countries is very small and almost insignificant. Fiji, Solomon Island and Vanuatu are an exception where consumption per capita is still high compared to other countries. This is partly because resources are still readily available locally, forest extent constitutes more than 70 percent of the total land area. Limited natural resources and dependency on fossil fuels have made these countries vulnerable to increased prices and uncertain supply, especially in rural areas.

Increased income and high rate of urbanization are unlikely to impact the woodfuel consumption pattern in the future in most of these countries. However, increased income will likely impact on countries where traditional biomass energy is still used. For example in Fiji, Solomon Islands and Vanuatu, as income increases, access to commercial energy sources is widely open and switching from traditional to more clean and convenient energy will likely occur. For low economy countries, there is always the possibility to switch back to use traditional biomass energy, when they cannot afford commercial energy source. Even if they

could afford commercial fuels, it is likely they will continue to use woodfuel as they find it cheaper, so they can save on the cost of cooking or heating (FAO, 1998). Critical issues and challenges for most of these countries are, among others, reducing heavy reliance on imported oil by exploring new possibilities of using renewable energy sources and limiting severe impact from increased in oil prices, as most of these countries have low per capita income (Table 7).

Table 7. Main energy issues in selected countries in Pacific Islands

Country	Forest area in 2005	Population in 2005			Main energy issues	Importance
	(000 ha)	Total (000)	Urban (%)	Rural (%)		
Cook Islands	-	14	73.3	26.7	Cost effective electricity supply; pilot sustainable renewable energy projects; capacity building	Priority in economic development
Fiji	1,000	828	53.2	46.8	Heavy reliance on fossil fuels; commercialization of rural electrification/electricity supply; capacity building	Economic development
Kiribati	2	92	50.2	49.8	Rural electrification; sustainable electricity for urban areas; energy efficiency and conservation; reducing the cost of landed petroleum products	To increase the standard of living of nationals through accessible, cost effective and environmentally friendly technologies
PNG	29,437	6,070	13.2	86.8	Reliance on fossil fuels; use of renewable energy; environmental protection	Priority in the resource development plan
Samoa	171	184	22.5	77.5	Develop human and institutional capacity; effective planning and management for development of sustainable energy projects; acceptance and enforcement of performance; environmental standards backed by appropriate legislation	Social and economic development Sustainable development and energy projects (renewable) Energy efficiency and conservation
Tonga	4	99	34	66	Dependence on imported petroleum products; Insufficient human and institutional capacity; Lack of information and energy awareness; Limited financial mechanisms	Priority in developing rural/remote areas and commercial activities
Vanuatu	440	215	23.7	76.3	High electricity tariff rates; Lack of human and institutional capacity; high dependency on imported fossil fuels; Need to develop alternate renewable energy technologies (geothermal)	Economic development

Source: FAO (2005); UN Common Database (2007); CROP (2000)

5. CONCLUSION

Woodfuel has been predominantly used in developing countries in the Asia-Pacific region for basic domestic uses and will remain an important source of energy in the future. Despite the fact that woodfuel consumption is showing a declining trend for most countries (for example countries in East Asia and Southeast Asia), woodfuel is certainly not phasing out yet for other countries, especially for most countries in South Asia. Persistent poverty has put these countries into a low affordability level that in turn will hinder the switching to modern energy sources. On the supply side, Cambodia, Vietnam and Myanmar are considered vulnerable and facing a critical woodfuel deficit. However, for small islands in this region, which are also mainly developing countries, woodfuel contributes a small portion (almost insignificant) for most of them, as they depend heavily on imported fossil fuels. Biomass is receiving greater attention, especially in developed countries, mostly as a means of reducing greenhouse gas emissions, increasing energy supply security and decreasing their heavy reliance on imported fossil fuels. Disruption of fuel supply and increase in oil price has made these countries turn to biomass energy as an alternative energy source.

6. REFERENCES

APERC. 2004. APEC Energy Overview. Asia Pacific Energy Research Centre. Tokyo.

Baumert, K.A., Herzog, T. and J. Pershing. 2005. Navigating the numbers: Greenhouse gas data and International climate policy. World Resource Institute.

Best, G. and J. Christensen. 2003. Role of biomass in global energy supply. Riso Energy Report 2. Riso, Denmark.

Carpenter, S.R., Pingali, P.L., Bennett, E.M. and Monika B. Zurek. 2005. Ecosystems and human well-being: scenarios: findings of the Scenarios The Millennium Ecosystem Assessment series; v. 2. Washington DC: Millenium Ecosystem Assessment.

Choi, Ki-Hong and Ang, B.W. 2001. A time-series analysis of energy-related carbon emissions in Korea. Energy Policy 29: 1155-1161.

CROP. 2000. Energy and Sustainable Development (Pacific Regional Submission to the 9th Session of the Commission on Sustainable Development (CSD9). Committee of Regional Organisations of the Pacific.

Domac, J., Richards, K. and V. Segon. 2005. Old fuel for modern times – socio economic drivers and impacts of bioenergy use. Renewables World News (http://www.renewable-energy world.com/display_article/272778/121/ONART/Display/none/1/Old-fuel-for-modern-times/)

Driscoll, D., Milkovits, G. and D. Freudenberger. 2000. Impact and use of firewood in Australia. CSIRO Sustainable Ecosystem.

Dzioubinski, O. and R. Chipman. 1999. Trends in Consumption and Production: household energy consumption. DESA Discussion Paper No. 6, United Nations Department of Economic and Social Affairs.

FAO. 1998. Asia Pacific Forestry Towards 2010: Report of the Asia Pacific Forestry Sector Outlook Study. FAO. Rome.

FAO. 2003. Past trends and future prospects for the utilisation of wood for energy, by J. Broadhead, J. Bahdon & A. Whiteman. Global Forest Products Outlook Study Working Paper GFPOS/WP/05. Rome. (In press.)

FAO. 2004. Unified Bioenergy Terminology. Rome, Food and Agriculture Organization of the United Nations.

FAO. 2005. Global Forest Resource Assessment 2005-Progress towards sustainable forest management. FAO Forestry Paper 147. Rome (also available at http://www.fao.org/docrep/008/a0400e/a0400e00.htm)

FAO. 2007. FAOSTAT Statistical Database. (http://faostat.fao.org/site/381/default.aspx)

FAO. 2007b. Wood-energy supply/demand scenarios in the context of poverty mapping – a WISDOM case study in Southeast Asia for the year 2000 and 2015. FAO. Rome.

Girard, P. 2002. “Charcoal production and use in Africa: what future?” Unasylva 211 (53): 30-34.

HEDON. 2006. Health, Safety and Household Energy Boiling Point No 52. HEDON Household Energy Network. London http://www.hedon.info/docs/BP52web.pdf

Hone, D. and Schmitz, S. 2004. Facts and trends to 2050: energy and climate change. World Business Council for Sustainable Development. Switzerland.

IEA. 2002. World Energy Outlook 2002 Edition – Energy and Poverty Chapter (pp. 365-393). International Energy Agency, Paris.

IEA. 2002b. Renewable energy. International Energy Agency. Paris

IEA. 2007. Potential contribution of bioenergy to the world's future energy demand. IEA Bioenergy. Paris.

Institute of Foresters of Australia. 2002. Wood for bioenergy. Forestry Policy Statement Vol. 8.1.

IPCC. 2001. Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. IPCC. Geneva.

OECD/IEA. 2006. World Energy Outlook 2006: Energy for cooking in developing countries. International Energy Agency. Paris.

OECD/IEA. 2007. Energy Balances of non-OECD Countries. International Energy Agency. Paris.

Oxley, A. 2005. Asia Pacific Partnership on Clean Development and Climate – New Prospect for Joint Strategies on Climate Change. Australian APEC Study Centre.

Rajagopal, D. and D. Zilberman. 2007. Review of Environmental, Economic and Policy Aspects of Biofuels. Policy Research Working Paper Series No. 4341. California: 107.

RWEDP. 1997. Regional study wood energy today and tomorrow in Asia. Working Paper APFSOS/WP/34.

Rebugio, L.L., Dizon, J.T. and N.O Espiritu. 2000. The Woodfuel Scenario and Policy Issues in the Philippines. Field Document No. 59. FAO. Rome.

Remedio, E.M. 2002. Wood energy and livelihood patterns: a case study from Philippines. Unasylva 211 (53):13-18.

Sadler, H., Diesendorf, M., and D. Richard. 2004. A clean energy future for Australia. Energy Strategies for the Clean Energy Future Group.

Saxena, N.C. 1997. The Woodfuel Scenario and Policy Issues in India. Field Document No. 49 1997. FAO. Rome.

Samson, R., Stohl, D., Elepano, A. and A. De Maio. 2001. Promoting biomass utilization in agricultural processing and in the home. In Samson et al (eds.). Strategies for enhancing household biomass energy use in the Philippines. National Renewable Energy Laboratory. Colorado.

Sega, S. 2007. Samoa Forestry Outlook Study. Draft Country Report.

Smeets, E.M.W. and A.P.C. Faaij (2007). Bioenergy potentials from forestry in 2050: An assessment of the drivers that determine the potentials. Climatic Change **81**(3-4):pp. 353-390.

Smith, K.R. 2006. Health impact of household fuelwood use in developing countries. Unasylva 224 Vol. 57. pp. 41-44.

Stucley, C.R., Schuck, S.M., Sims, R.E.H., Larsen, P.L., Turvey, N.D. and B.E. Marino. 2004. Biomass energy production in Australia: Status, costs and opportunities for major technologies. A report for the RIRDC/FWPRDC L&W Australia/MDBC. Joint Venture Agroforestry Program. RIRDC Publication No.04/031.

Tomaselli, I. 2007. Forest and Energy in Developing Countries. Rome, Food and Agriculture Organization of the United Nations.

UN. 2007. "United Nations Common Database."

UNDP. 2007. Human Development Report 2007/2008 Fighting climate change: human solidarity in a divided world. UNDP, New York.

UN. 2006. Trends in Sustainable Development. United Nations, Department of Economic and Social Affairs. New York.

UNED Forum. 2002. Towards Earth Summit 2002: Climate change and energy - can we weather the switch to sustainable energy? Environmental Briefing No. 2.

UNESCAP. 2007. The Millenium Development Goals: Progress in Asia and the Pacific 2007. Asia Pacific MDG Study Series. United Nations Economic and Social Commission for Asia and the Pacific. Bangkok

Victor, N.M. and D.G. Victor. 2002. Macro Patterns in the Use of Traditional Biomass Fuels. Stanford, Stanford University: 31.

WEC. 2007. 2007 Survey of energy resources. World Energy Council. London.

Whiteman, A., Broadhead, J. and J. Bahdon. 2002. The Revision of Woodfuel Estimates in FAOSTAT. Unasylva 211 (53): 41-45.

Whiteman, A. 2005. Trend and Challenges in the Forestry Sector in Small Island Developing States. Forestry Sector Outlook Studies - GFPOS/MISC/03.

WHO. 2007. Indoor air pollution: National burden of disease estimates.

WHO. 2000. Addressing the link between indoor air pollution, household energy and human health.

World Bank. 2006. World Development Indicator. http://devdata.worldbank.org/wdi2006/contents/cover.htm (accessed in October 2007)

7. ANNEXES

Annex 1. Share of woodfuel production in total roundwood production in 2005

Countries	Total Forest area	Primary forest	Plantation	Roundwood production	Woodfuel production	Share woodfuel in total roundwood production
	1000 ha	1000 ha	1000 ha	(000 cum)	(000 cum)	(%)
Australia	163,678	5,233	1,766	30529	5601	18.3
Bangladesh	871	-	279	27944	27662	99.0
Bhutan	3,195	413	2	4679	4546	97.2
Brunei Darussalam	278	278	-	229	12	5.1
Cambodia	10,447	322	59	9334	9221	98.8
China	197,290	11,632	31,369	286103	191042	66.8
Cook Islands	16	-	1	5	0	0.0
Fiji	1,000	894	101	509	37	7.3
India	67,701	-	3,226	328677	305485	92.9
Indonesia	88,495	48,702	3,399	106216	73720	69.4
Japan	24,868	4,591	10,321	16276	110	0.7
Kiribati	2	-	-	0	0	0.0
Korea, DPR	6,187	852	-	7297	5797	79.4
Korea, Republic of	6,265	-	1,364	4877	2465	50.5
Lao PDR	16,142	1,490	224	6336	5944	93.8
Malaysia	20,890	3,820	1,573	28237	3068	10.9
Maldives	1	-	-	0	0	0.0
Mongolia	10,252	4,733	112	631	186	29.5
Myanmar	32,222	-	849	42548	38286	90.0
Nepal	3,636	349	53	13952	12692	91.0
New Caledonia	717	431	10	5	0	0.0
New Zealand	8,309	3,506	1,852	19143	0	0.0
Pakistan	1,902	-	318	29270	26500	90.5
Papua New Guinea	29,437	25,211	92	0	5533	*
Philippines	7,162	829	620	15819	12950	81.9
Samoa	171	n.s.	32	131	70	53.4
Singapore	2	2	0	0	0	0.0
Solomon Islands	2,172	-	-	692	138	19.9
Sri Lanka	1,933	167	195	6278	5584	88.9
Thailand	14,520	6,451	3,099	28566	19866	69.5
Tonga	4	-	n.s.	2	0	0.0
Vanuatu	440	-	-	119	91	76.5
Viet Nam	12,931	85	2,695	31587	26350	83.4
Asia Pacific				**1045992**	**780471**	**74.6**
World				**3532083**	**1823501**	**51.6**

Note: n.s.: not significant, indicating a very small value
Source: FAO GFRA (2005); FAOSTAT (2007)

Annex 2. Burden of disease due to indoor air pollution from solid fuel use for the year 2002 in Asia Pacific region (WHO 2007)

Country	Percentage of population using solid fuel	ALRI[6] deaths attributable to solid fuel use (<5 years)	COPD[7] deaths attributable to solid fuel use (30 years)	Lung cancer deaths attributable to coal use (30 years)	Total deaths attributable to solid fuel use***	Total DALYs[8] attributable to solid fuel use	Percentage of national burden of disease attributable to solid fuel use
Australia	<5	0	0	0	0	0	0.0
Bangladesh	89	32 330	13 620	0	46 000	1 316 400	3.6
Bhutan	no data	0	0	0	0	0	0.0
Brunei	no data	0	0	0	0	0	0.0
Cambodia	>95	1 280	330	0	1 600	52 300	1.0
China	80	20 540	342 450	17720	380 700	3 204 900	1.6
Cook Islands	no data	0	0	0	0	0	0.0
Fiji	40	20	20	0	<100	1 200	0.8
India	82	251 560	155 250	340	407 100	10 646 500	3.5
Indonesia	72	3 130	12 160	0	15 300	320 800	0.7
Japan	<5	0	0	0	0	0	0.0
Kiribati	no data	0	0	0	0	0	0.0
Lao PDR	>95	1 900	530	0	2 400	77 100	3.5
Malaysia	<5	<10	20	0	<100	300	0.0
Maldives	no data	0	0	0	0	0	0.0
Mongolia	51	240	30	0	300	9 200	1.6
Myanmar	>95	11 590	3 070	0	14 700	469 200	3.2
Nepal	81	4 820	2 680	0	7 500	204 400	2.7
New Zealand	<5	0	0	0	0	0	0.0
Pakistan	81	51 760	18 980	<10	70 700	2 057 400	4.6
PNG	90	990	560	0	1 600	51 200	3.2
Philippines	45	5 520	1 400	20	6 900	238 100	1.6
Rep of Korea	<5	0	0	0	0	0	0.0
Samoa	70	0	0	0	0	400	1.3
Singapore	<5	0	0	0	0	0	0.0
Solomon Islands	95	40	30		<100	2 000	1.9
Sri Lanka	67	100	3 030	0	3 100	44 500	1.3
Thailand	72	1 850	2 710	0	4 600	95 900	0.8
Tonga	56	0	0	0	0	200	1.0
Vanuatu	79	0	0	0	0	300	0.8
Viet Nam	70	2 620	7 810	150	10 600	157 100	1.2

* The total deaths attributable to solid fuel use were rounded and may not be equal to the sum of ALRI, COPD and lung cancer deaths.

[6] ALRI: acute lower respiratory infections
[7] COPD: chronic obstructive pulmonary disease
[8] DALY: Disability-Adjusted Life Year, to compare diseases or risk factors in terms of their public health importance, combining the years of life lost due to disability with the years of life lost due to death

Annex 3. Data on population, gross domestic product and total woodfuel consumption in 2005

No	Country	Population			Percent of population		Gross Domestic Product		Woodfuel consumption	
		Total	Urban	Rural	Urban	Rural	(million USD)	per capita	Total (000 m3/yr)	per capita
1	Australia	20,310	18,828	1,483	92.7	7.3	732,779	36,079	8,445	0.42
2	Bangladesh	153,281	38,320	114,961	25	75.0	60,034	392	27,662	0.18
3	Bhutan	637	58	579	9.1	90.9	828	1,299	4,546	7.14
4	Brunei Darussalam	374	290	84	77.6	22.4	6,400	17,120	12	0.03
5	Cambodia	13,956	2,749	11,206	19.7	80.3	6,194	444	9,221	0.66
6	China	1,312,979	531,756	781,222	40.5	59.5	2,243,853	1,709	207,251	0.16
7	Fiji	828	441	388	53.2	46.8	2,729	3,296	93	0.11
8	Hong Kong, China	7,057	7,057	-	100	-	177,783	25,191	95	0.01
9	India	1,134,403	325,574	808,829	28.7	71.3	805,732	710	305,485	0.27
10	Indonesia	226,063	108,284	117,779	47.9	52.1	286,961	1,269	82,194	0.36
11	Japan	127,897	84,028	43,869	65.7	34.3	4,533,965	35,450	1,234	0.01
12	Kiribati	92	46	46	50.2	49.8	66	721	3	0.03
13	Korea, Rep.	47,870	38,679	9,191	80.8	19.2	791,427	16,533	2,465	0.05
14	Lao PDR	5,664	1,223	4,441	21.6	78.4	2,882	509	5,944	1.05
15	Malaysia	25,653	16,700	8,953	65.1	34.9	130,770	5,098	3,068	0.12
16	Maldives	295	88	208	29.7	70.3	756	2,560	14	0.05
17	Mongolia	2,581	1,471	1,110	57	43.0	2,096	812	621	0.24
18	Nepal	27,094	4,281	22,813	15.8	84.2	7,391	273	12,692	0.47
19	New Zealand	4,097	3,524	574	86	14	109,291	26,675	542	0.13
20	Pakistan	158,081	55,012	103,069	34.8	65.2	111,299	704	25,899	0.16
21	Papua New Guinea	6,070	801	5,269	13.2	86.8	4,945	815	754	0.12
22	Philippines	84,566	52,938	31,628	62.6	37.4	98,366	1,163	12,950	0.15
23	Samoa	184	41	142	22.5	77.5	404	2,197	8	0.04
24	Singapore	4,327	4,327	-	100	-	116,693	26,966	35	0.01
25	Solomon Islands	472	81	392	17.1	82.9	298	631	122	0.26
26	Sri Lanka	19,121	4,015	15,105	21	79	23,538	1,231	5,584	0.29
27	Thailand	63,003	20,476	42,527	32.5	67.5	176,222	2,797	19,866	0.32
28	Tonga	99	34	66	34	66	215	2,159	2	0.02
29	Vanuatu	215	51	164	23.7	76.3	368	1,709	42	0.20
30	Vietnam	85,029	22,703	62,326	26.7	73.3	52,917	622	26,350	0.31
	World	**6,514,751**	**3,172,684**	**3,342,067**	**48.7**	**51.3**	**44,795,448**	**6,876**	**1,920,253**	**0.29**

Annex 4. Cluster of countries based on income level categories[9]

		Population			Percent of Population		Gross Domestic Product		Woodfuel consumption	
		Total	Urban	Rural	Urban	Rural	(000 USD)	per capita	Total (000 m3/yr)	per capita
	Low Economies Countries (GDP per capita ≤ 905 USD)									
1	Nepal	27,094	4,281	22,813	15.8	84.2	7390748	273	12,692	0.47
2	Bangladesh	153,281	38,320	114,961	25	75.0	60033524	392	27,662	0.18
3	Cambodia	13,956	2,749	11,206	19.7	80.3	6194302	444	9,221	0.66
4	Lao PDR	5,664	1,223	4,441	21.6	78.4	2881701	509	5,944	1.05
5	Vietnam	85,029	22,703	62,326	26.7	73.3	52917359	622	26,350	0.31
6	Solomon Islands	472	81	392	17.1	82.9	298118	631	122	0.26
7	Pakistan	158,081	55,012	103,069	34.8	65.2	111298888	704	25,899	0.16
8	India	1,134,403	325,574	808,829	28.7	71.3	805732024	710	305,485	0.27
9	Kiribati	92	46	46	50.2	49.8	66361	721	3	0.03
10	Mongolia	2,581	1,471	1,110	57	43.0	2096014	812	621	0.24
11	Papua New Guinea	6,070	801	5,269	13.2	86.8	4945034	815	754	0.12
	Middle Economies Countries (GDP per capita 906-11,115 USD)									
12	Philippines	84,566	52,938	31,628	62.6	37.4	98366087	1163	12,950	0.15
13	Sri Lanka	19,121	4,015	15,105	21	79	23538239	1231	5,584	0.29
14	Indonesia	226,063	108,284	117,779	47.9	52.1	286961402	1269	82,194	0.36
15	Bhutan	637	58	579	9.1	90.9	827501	1299	4,546	7.14
16	Vanuatu	215	51	164	23.7	76.3	367978	1709	42	0.20
17	China	1,312,979	531,756	781,222	40.5	59.5	2243852501	1709	207,251	0.16
18	Tonga	99	34	66	34	66	214514	2159	2	0.02
19	Samoa	184	41	142	22.5	77.5	403922	2197	8	0.04
20	Maldives	295	88	208	29.7	70.3	755931	2560	14	0.05
21	Thailand	63,003	20,476	42,527	32.5	67.5	176221700	2797	19,866	0.32
22	Fiji	828	441	388	53.2	46.8	2728918	3296	93	0.11
23	Malaysia	25,653	16,700	8,953	65.1	34.9	130769977	5098	3,068	0.12
	High Economies Countries (GDP per capita ≥ 11,116 USD)									
24	Korea, Rep.	47,870	38,679	9,191	80.8	19.2	791426892	16533	2,465	0.05
25	Brunei Darussalam	374	290	84	77.6	22.4	6399988	17120	12	0.03
26	Hong Kong, China	7,057	7,057	-	100	-	177782653	25191	95	0.01
27	New Zealand	4,097	3,524	574	86	14	109291430	26675	542	0.13

[9] Income group is based on the World Bank classification (2007) with modification, where lower middle income (906-3,595 USD) and upper middle income (3,596-11,115 USD) are combined into middle income category.

28	Singapore	4,327	4,327	-	100	-	116693402	26966	35	0.01
29	Japan	127,897	84,028	43,869	65.7	34.3	4533965029	35450	1,234	0.01
30	Australia	20,310	18,828	1,483	92.7	7.3	732778988	36079	8,445	0.42