Government of Nepal

Water and Energy Commission Secretariat

Singhadurbar, Kathmandu, Nepal

Energy Sector Synopsis Report

July 2010

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FOREWORD

It gives me a great pleasure to publish the Energy Sector Synopsis Report 2010 which is the eighth of its kind in WECS publication series.

Water and Energy Commission Secretariat (WECS) has been working in the preparation of Energy Sector Synopsis Report of Nepal since its establishment in 1975. Energy Planning Division of the WECS has collected baseline information through primary survey as well as available secondary information while preparing this energy report. We deem that the report will provide the basic information about available energy resources in the country and their distribution in the different parts of the country particularly by different physiographic regions and development regions. The primary objective of this report is to present updated energy supply and consumption information of the country to all stakeholders. This report, therefore, provides the basis of energy information system while analyzing the energy sector of the country.

WECS has conducted and involved in various studies, research, surveys, workshops etc for the promotion and development of energy sector. Recently it has prepared the draft National Energy Strategy. WECS is also planning to have next round of primary data collection regarding the energy supply and consumption system of the country at national and regional level.

The report is believed to be useful for all involved in national energy planning as well as academic research and studies of the energy sector. It further gives the ideas about the interrelationship between indigenous energy resources availability and consumption scenario which will enable to understand the intervention needed to meet the challenges and opportunities for sustainable energy development in the country.

Mr. Deepak Kumar Kharal, Senior Energy Officer, WECS has made immense effort in preparing this report for which he deserves a special appreciation. He has untiringly collected scattered energy information from different institutions and compiled and updated it from energy perspective. I am also thankful to Iswar Singh Thapa, Joint Secretary (Head of Energy Planning Division), Suresh Raj Uprety, Joint Secretary and Sanjay Dhungel, Senior Divisional Engineer and Madhav Dev Acharya, Engineering Geologist, for their review and suggestion to give final shape of the report.

Any comments, suggestions, remarks and observation on this report is highly appreciable since it provides a valuable feedback to improve the document in the future publications. Finally, I believe that this report will be useful and valuable for all those involved and concerned in the energy sector.

Shyam Prasad Mainali
Secretary

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Acronyms and Abbreviations

AEPC	Alternative Energy Promotion Center
ATF	Aviation Turbine Fuel
BSP	Biogas Support Program
CDR	Central Development Region
DDC	District Development Committee
DFO	District Forest Office
DFRS	Department of Forest Research and Survey
DM&G	Department of Mines and Geology
DoF	Department of Forest
EDR	Eastern Development Region
FAO	Food and Agricultural Organization
FWDR	Far- Western Development Region
FY	Fiscal Year
GDP	Gross Domestic Product
GJ	Giga Joule
GWh	Giga Watt Hour
HH (hh)	Household
HS Diesel	High Speed Diesel
ICIMOD	International Center for Integrated Mountain Development
ICS	Improved Cook Stove
INGO	International Non- Governmental Organization
KCAL	Kilo Calories
LDO	Light Diesel Oil
LPG	Liquefied Petroleum Gas
LRMP	Land Resources Mapping Project
MFSC	Ministry of Forest and Soil Conservation
MH	Micro-hydro
MHP	Micro-hydro Plant
MPFS	Master Plan for Forestry Sector
MS	Motor Spirit
MT	Metric Ton
MW	Megawatt
MWDR	Mid- Western Development Region
MWh	Megawatt Hour
NCI	Non Cultivated Inclusion
NEA	Nepal Electricity Authority
NFI	National Forest Inventory
NGO	Non-governmental Organization
NOC	Nepal Oil Corporation
NRs	Nepalese Rupees
TCE	Tons of Coal Equivalent
TCN	Timber Corporation of Nepal
TOE	Tons of Oil Equivalent

TE	Traditional Energy
WDR	Western Development Region
WECS	Water and Energy Commission Secretariat
MOWR	Ministry of Water Resources

Chapter 1: Country Background

1.1 Landscape

Nepal is characterised with large number of beautiful landscape having diverse topographical, geographical and physiographical situation within a span of 200 kilometres distance from south to north and about 800 kilometers distance in east west direction. Within this short span, the elevation ranges from below 100 meters in south to 8848 meters in northern part. Nepal may be divided into geographic, physiographic or ecological zones. Different versions are found regarding the types of landscape found in different categories. Rugged hills and mountains cover more than 80% of the land. It has eight of the world's highest peaks, including Mt. Everest. In the south, there is a belt of almost plain land 20 to 40 kilometer wide, which is the extension of the Gangatic plain of India.

Country has five major physiographic landscapes extending from east to west. High Himalaya region is situated above 3000 meter elevation occupying about 23% of Nepal which is mostly covered by snow and ice all the year. High Mountain region is located below the High Himalaya region which is at 2300-3000 meters elevation on the ridges and top of the mountain but this area also goes upto the 1000 meter elevation in the valley and gorges. Middle Mountain region is the great central belt of Nepal covering about 30% of the country's land. This belt is composed mostly with the network of mountain ridges and valleys and small portion is found with flat land. Siwalik zone is located below the middle mountain region, with a series of low, hogback ridges in a twisting pattern. It is the first and lowermost ridges of the Himalayan Mountain system. They enclose several cultivated valleys and plains. The zone occupies about 13% of the country at an elevation of 120 to 2000 meter. Terai region is the outer most part of country's physiography going through north to south. This region ranges from about 50 to 330 meters with a gentle southward slopes. It covers about 14% of the land surface.

1.2 Climate

At global level, Nepal lies within the subtropical monsoon climatic region but because of its varied topographical situation and elevation, it enjoys the wide range of climates. The low land and the Siwalik region have a hot monsoon or subtropical climate with hot, wet summers and mild, dry winters. The lower middle mountains, up to about 2000 meter elevation, have a warm temperate monsoon climate with warm, wet summers and cool, dry winters. The Middle Mountains at around 3000 meter elevation have a cool temperate monsoon climate, with mild wet, wet summers and cool, dry winters. The high mountains, at around 4000 meters elevation, have an alpine climate, cool summers and frosty winters. The high Himalayan above the snowline has a tundra type arctic climate, with perpetual frost and cold desert conditions.

Precipitation varies greatly from one place to another. The average annual rainfall ranges from 250 to 4500 mm.

1.3 Demography

There were 9.4 million people in the country in 1961 which reached to 15 million in the year 1981. The next population census was taken in 1991 according to which total population was 18.4 million. The last population census was taken in 2001. This census found out 23.1 million populations with an annual rate of growth equal to 2.25% which is still high when compared with the international level. If this growth rate continues, Nepal's current population will double in the next 31 years. Whereas the total fertility rate was 6.3 on average in 1980s, this has decreased to 3.1. Population distribution is very unequal in terms of physiographic areas. Only about 7% people lives in Mountain region. This region occupies about 35% of the total land area. Population in mountain region is somehow similar with the land area. Because Hilly region occupies about 42% of the total land and support about 44% people to live in. Terai region of the country is more fertile and plain. Only 23% of the country's land is located in this region. However, this region supports 49% of the population. Although the total fertility rate is decreasing in urban areas, the rate of population growth in the rural areas is still very high. The number of children and elderly is still high in Nepal's population structure as a result the number of elderly and dependents is increasing. Due to the migration of male population, there are currently 89 males to 100 females. Expected targets have not been reached in reproductive health. Similarly, there is repetition in implementation of population related programs, and there is lack of coordination between sectoral agencies.

1.4 Economy

Gross Domestic Product (GDP) indicates the economic status of the country to a great extend. Total GDP at current prices in the year 2007/08 and 2008/09 were about NRs. 728.18 billion and 818.4. billion respectively. The real GDP at produces' prices increase by 3.1% in 2007/08 and 5.3% in 2008/09. Contribution of agriculture, forestry and fishery sector to GDP in 2008/09 is estimated at 32.4 percent.

Growth rate of non-agriculture sector in 2008/09 is estimated at 5.7 percent. This growth rate is less as compared to previous fiscal year. Major reason for this decline is the shortage of energy supply. Sub-sector that recorded negligible or negative growth is electricity, gas and water. This sub-sector is estimated to record a negative growth of 1.1 percent.

Observation of the structure of GDP shows among the production sector of the economy, agriculture occupied 32.4 percent, followed by wholesale and retail trade 13.7 percent, transport, communication, and warehousing 10.5 percent. Among other remaining sub-sectors, real estate and professional services 8.3 percent, manufacturing industry 6.8 percent, and construction 6.4 percent. Likewise, education, financial intermediation, and electricity, gas and water have their respective 6.0 percent, 4.8 percent, 1.7 percent shares to GDP. Of the remaining portion, education, public administration, and defence shared 2.0 percent, hotel and restaurant 1.5 percent, and health and social works contributed 1.3 percent to GDP.

1.5 Finance

Nepal Rastra Bank, as the Central Bank of the country with its responsibility for the overall monetary management, has been regularly making public the Annual Monetary Policy since 2002/03. Such policy includes credit, foreign exchange, micro-finance, regulation and supervision of financial system and programs of the monetary sector as a whole. These policies have given high priority especially to internal stability (price stability and financial sector's stability) and external stability (favourable balance of payments and consolidation) as the main objectives of monetary policy. In addition, Policy and Programmes are designed with priority accorded to other objectives as mentioned in Nepal Rastra Bank Act.

Looking at the financial transaction statistics of the government of Nepal, the total expenditure in the fiscal year 2007/08 was Rs. 161.35 billion of which 56.7 percent was current expenditure, 33.2 percent was capital expenditure, and 10.1 percent was expenses against principal repayment. Expenditure trend of the last couple of years shows share of recurrent expenditure in the total expenditure close to 60 to62 percent from FY2001/02 to FY2005/06. The share of capital expenditure in the total expenditure was about 26 percent during the fiscal years 2001/02 to 2005/06. During this period, total average revenue increased by 13.7 percent, while average growth rate of total expenditure has been 12.6 percent.

Revenue mobilization, foreign grants and loan, domestic borrowings and change in cash reserves are used as fiscal instruments for financing government expenditures. Revenue mobilization in FY2007/08 increased by 22.7 percent to Rs107.625 billion. The Government revenue had financed 66.7 percent of the total expenditure in FY 2007/08.

1.6 Transportation

1.6.1 Road services

Total road length by now is totaled 19,147 Km, of which black topped road is 5,845 km, graveled is 4,711 km, and earthen (fair weather) road is 8,591 km. The number of vehicles (registered) across the country between fiscal years 1989/90 and 2007/08 stood at 703,044. The average ratio of vehicles per Kilometer of road across the country is estimated to 40. The process is initiated towards modernizing the transport management work through various measures including, regular departmental monitoring of TMOs, and making the record keeping system more scientific and systematic.

1.6.2 Air transport services

There are altogether 53 airports in the country including, 1 international airport, 5 regional hub airports, 41 other domestic airports with 6 airports under construction Of these, air services are operated at 32 airports. As per the policy of encouraging private sector airlines for the operation of domestic and international air services, 47 airline companies have been issued with Airline Operation Certificate (AOC). Twenty international airlines companies have been operating regular air services by making Nepal one of their destinations. Five international airlines started their services to Nepal in the last fiscal year, while one more airline has started its services beginning from this fiscal year. In this way, the numbers of Aviation sports-related airlines and the remarkable extension in the service have given expected service to the tourists, resulting in

significant contribution to the tourism industry. With the development and expansion of international airlines services, the tourism industry and trade of Nepal have received additional support. Nepal has signed Bilateral Air Service Agreements (ASA) with 35 countries.

1.7 Energy Resources

Nepal's energy resources are presently classified into three categories namely the traditional, commercial and alternative. Traditional energy resources include fuel wood from forests and tree resources, agricultural residues coming from agricultural crops and animal dung in the dry form. Traditional energy resources can, of course, be termed as biomass energy resources since it only covers the bio materials for energy purpose. Energy resources coming under the commercial or business practices are grouped into commercial energy resources that particularly include the coal, grid electricity and petroleum products. Biogas, solar power, wind and micro level hydropower are categorised into the alternative energy resources in Nepal. Such resources are considered as the supplement of conventional energy resources.

Total energy consumption in the year 2008/09 was about 9.3 million tonnes of oil equivalent (401 million GJ) in the country out of which 87% were derived from traditional resources, 12% from commercial sources and less than 1% from the alternative sources.

1.8 Water Supply

There has been extensive increase in the participation of consumer groups in the construction, operation and maintenance of drinking water systems. According to the Nepal Population and Health Survey, 2008, some 90 percent of urban households and some 80 percent of rural households have access to drinking water. Similarly, in sanitation, about 37 percent of urban households, and 20 percent of rural households are using improved latrines. From the administrative records, it is found that some 77 percent of the population has access to drinking water, and some 46 percent of the population is using proper latrines. The supervision and coordination of various agencies working in the sector of drinking water and sanitation is found to be weak, and necessary facilities have not been provided in many places. In addition, adequate attention has not been paid in improving the quality of drinking water, or in adequately maintaining drinking water systems that have been constructed. The awareness level of women has increased as a result of active engagement of the non-governmental sector and the civil society in protection of women's rights. However, it is felt that there has not been adequate improvement in the legal provisions, development programs and budget allocation for gender equality.

Chapter 2: Energy Resource Bases of Nepal

2.1 Biomass based Energy Resources

Bioenergy implies the energy derived from organic biomass of recent origin available in different forms (solid, liquid or gas), from forestry, agriculture and other sectors. It included woodfuels, agrofuels and others, including mixtures plant and animal materials available on a renewable basis. It means the availability of biomass resources for energy production exists in abundance in the country.

The common biomass fuels that fall under the classification of Traditional Energy (TE) in Nepal included only the solid biomass fuels derived from plants and animals. Both woody and non-woody biomass derived from forests, shrub and grass lands and agricultural lands (crop harvesting and processing residues), as well as residues of animals in the form of excreta (mostly cattle dung). Recently the charred materials of some wild shrubs and other loose biomass materials were being compressed into biomass briquettes for energy.

The new boundary of Traditional Energy Resources (TER) extended beyond the territory of the forestry sector, embraced all types of trees, shrubs and herbaceous plants grown both inside and outside of forests, including non-forest lands, such as agricultural lands as well as organic waste materials derived as by-products of plant and animals, including industrial wastes, municipal solid wastes, etc. The new territory of bioenergy, therefore, encompassed the agriculture, livestock, industry and human settlement sectors besides the forestry sector. Therefore, bioenergy called for integration of the development activities in all of these related sectors.

Besides, the Environment sector, although it was not directly responsible for biomass production for energy, could influence through its policy and legislation in the development and use of modern bioenergy applications, through proper management of industrial and municipal biomass wastes by sing them for energy production, also for reduction in atmospheric emission of greenhouse gases (GHGs). The human settlement sector could also play a significant role in this regard. In many countries the energy potential of municipal and industrial wastes and by-products was being realized for heat, power generation instead of wasting them.

Biomass is the major sources of energy particularly in rural Nepal. Biomass fuels consist of both woody and non-woody biomass. The first come from trees and shrubs, the latter from crop residues and other vegetation. Fuelwood from forest and tree resources, charcoal mainly from woody biomass, residues from different agricultural crops and animal dung are the major biomass based energy resources.

From the total TE consumption volume point of view, fuelwood stands first amongst different types of TE sources. Until recently, the use of charcoal for domestic energy has also remained insignificant. No forest in Nepal has been managed solely for energy purpose. Most fuelwood collected/assembled currently are either in the form of logging residues in forests derived after tree harvesting or in the form wood-processing by-products such as *bakal, tukra-taktri, chilka, kathko dhulo etc,* generated in saw mills and furniture factories. Some woody residues with energy potential are also generated in plywood, particleboard and fiberboard factories. The use

of chemical pulpwood residue (black liquor, in liquid form) for energy production has neither been acknowledged nor reported in the statistics of related sector. The other important components of TE according to their ranking in total TE supply included the residues of animals and crops, respectively.

2.1.1 Woodfuel Resources

Woodfuels consist of woody biomass, i.e. stems, branches, twigs, etc., and saw dust and other residues from logging and wood processing activities, as well as charcoal from these sources. The primary sources of woodfuels are both forest and non-forest land. Forest and other wooded land include natural forests (including degraded forests), shrub lands, wood and timber plantations and woodlots, grasslands, non cultivated inclusion. Non-forest land here includes agricultural land, agro-forestry systems, road side plantation, home gardens, etc.

Currently, accessible National Forests (areas with more than 10% crown cover) and shrublands (areas with less than 10% crown cover) as well as private and community forests, tree plantations in block or linear lines, play a crucial role in fuelwood supply. These forests could be natural in origin or in the form of trees plantations, in blocks, lines or as scattered trees in public and community lands. Besides, private forests, and trees, including trees grown in non-forest lands of different types also contribute to both locally consumed and commercially traded fuelwood production.

All forests, excluding private forests, whether marked or unmarked with forest boundary markers are treated as national forests, including waste or uncultivated lands, unregistered lands surrounded by or adjoining to forests, as well as paths, ponds, lakes, rivers or streams and riverine lands within forests. The legal definition of forest, according to MFSC-DoF (1999), includes all fully or partly covered areas by trees, including land use types such as Forest, Shrub land, Grassland, Non-cultivated inclusions, and other lands. Except the cultivated land, which is mostly registered under private or institutional ownership, all other land use types are owned and managed by the forestry or other related agencies in the public sector.

Nepal's forest resources have been regulated by Forest Act, 1993 and Forest Regulation 1995. This law and regulation has classified the forest into two broad categories for the management purpose. Such categories are National forests and Private forests. Nepal's current forest policy and legislation make a provision to earmark the national forests into a number of categories namely the Community forest, Leasehold forest, Government managed forest, Religious forest and the protected forest. Such categories were made to support the management purpose of the forests. Collaborative Forest regime is also added in Nepalese forest management system through the government directive. Additionally, buffer zone of the protected areas are also providing large amount of fuelwood resources for locals. National Parks and Wildlife Conservation Act (1973) and Regulation has also categorized different forest type namely the Bufferzone Community forest, Bufferzone Leasehold Forest and Bufferzone Religious Forest and Buffer zone private forest.

Forest land, shrub land, grass land, non-cultivated inclusion and cultivated land are the major land use types in Nepal where forests and tree resources are existed in different intensity. The

remaining land uses are grouped into other land categories that includes water bodies, ice and snow coverage, rocky slopes etc.

2.1.1.1 Present Practice of Fuelwood Production and Supply

As already mentioned, National and Leasehold Forest, Community and Private Forest are the major sources of wood products. Role of Government Managed Forest in this regard is highly significant. However, Community and Private Forest also produce a large amount of fuelwood for fulfilling the need of household, commerce and industrial sector.

The following institutions have been established and working in connection to supplying the wood/fuelwood requirement of the people:

1. District Forest Office (DFO)
2. District Committee for Forest Product Supply
3. Forest Product Development Committee
4. Forest User Group
5. Private Forest

District Forest Office is the solely responsible for producing and supplying the wood and fuelwood requirement of the people through scientific management of the Government Managed Forest. Once the District Forest Office collects and receives the trees and logs and wood from its authorized area, first the wood requirement of the District Committee for the Forest Product Supply is allocated and then remaining portion is distributed to the Timber Corporation of Nepal (TCN) and other parties/individuals equally.

Timber Corporation of Nepal is a fully government owned institution working for supplying the logs, timbers and fuelwood to the people living in both rural and urban areas in reasonable price. TCN also receives the forest products directly from the DFO or produce such materials after getting the woodlots assigned by the DFO.

Forest Product Development Committee has also been working in the field of increasing the forest productivity through planting fast and rapidly growing exotic plant species in the heavily degraded forest area. The wood receiving from clear cutting of such forest land is largely used for fuel purpose including wood and poles and supply to the local users and forest based industries as well.

Forest User Group is an established and autonomous body recognized by Forest Act, 1993. FUG receives the tenure right of part of the National Forest as a Community Forest which is fully authorized in conservation, management and utilization of forest product from such forest type. Recently there are more than 14,000 number of FUG and 1.2 millioin hectare of land under the community forestry system. Large amount of fuelwood have been derived from such forest type as a major contribution.

Trees and forest resources growing specially in the private farmland also supply huge amount of fuelwood. Land owner him/herself is responsible for selecting tree species, managing,

conserving and utilizing the forest products. However, it is necessary to get approval from the DFO if the forest products of private forest and land are to be transported outside district.

2.1.1.2 Status of Forest Resources in Nepal

Forest and tree resources of Nepal were assessed in different time period. Some assessment was made in terms of area whereas some other assessment was made both in area and stock level. The first assessment of the forest resources goes back to 1960s covering the Terai and adjoining Hill districts of Nepal. The second assessment was made only in terms of area for the year 1978/79 from Land Resource Mapping Project (LRMP). MPFS (1988) assessed the forest resources both in area and stock with some field study for the year 1985/86. Another assessment was done during 1987 to 1998 from DFRS with the support from FINNISH government. District wise forest statistics was also estimated by JAFTA in 2001 analysing the remote sensing image. The recent assessment was completed in 2004 to find the area coverage of 20 Terai districts of Nepal. Forest Resources Assessment Project is recently being conducted by DFRS with the support from FINNISH government using LiDAR technology. The details of the forest status is presented for the different time period hereafter.

2.1.1.3 Forest Resources in 1960s

Table 2.1 shows the summary finding of the forest resources assessment of 1960s. About 6.4 million hectares of forest and shrubland was assessed for the year 1964/65 out of which only about 58% is covered by crown, 6% by shrubland and remaining area is not covered by crown within the forest land. Within the forest land about 17% is found within the lower stocking level. About 42% forest is found in medium stocking and remaining 41% forest was highly stocked in the same duration.

Table 2.1: Estimated area of forests and shrubland in 1964/65 in Nepal

Area in 000' ha

Category	Forest land			Shrubland	Forest & Shrubland	Percent
	Crown Cover Class					
	10-40	40-70	70-100			
Forest & Shrub land	1021.8	2554.4	2502.7	388.0	6466.9	100.0
Crown cover %	25	55	85			
Crown coverage	255.5	1404.9	2127.3		3787.7	58.6
Shrub land					388.0	6.0

Sources: WECS (1983)

This assessment doesn't include the forest and shrubland of High Himals of Nepal.

2.1.1.4 Forest Resources in 1970s

The area assessment of the forest up to district level was completed for the year 1978/79. This second assessment was based on aerial photo interpretation. Land Resources Mapping Project (LRMP) estimated the area coverage of each land category. WECS (1988) has carried out a detail analysis of aerial photo of the 1978/79 and classified the land use as shown in table 2.2.

Table 2.2: Land use classification and area in 1978/79 in Nepal

Unit in 000 ha.

Landuse type	Development region					Grand Total
	EDR	CDR	WDR	MWDR	FWDR	
Forest	948.7	1104.0	923.7	1646.9	989.2	5612.4
Shrubland	192.1	223.7	137.4	80.1	60.8	694.0
Grassland	178.1	142.5	436.6	783.7	215.1	1755.9
NCI	236.7	234.7	226.6	177.3	111.7	986.9
Cultivated land	838.4	791.0	593.0	453.8	293.2	2969.4
Otherland	460.1	238.5	618.4	1138.4	274.4	2729.8
Grand Total	2854.1	2734.3	2935.5	4280.2	1944.3	14748.5

Source: WECS (1988)

This information was derived from the LRMP work. About 42% of the total land was found under forest and shrubland categories. Trees and woody plants are found in their natural state in such land types. The second largest land use was cultivated land which was about 20% of the total land surface of that time. Grassland occupied about 12% of the total whereas shrubland was just about 4%. Snow cover, ice cover, rocky land, water surface etc were grouped into otherland category which was about 18% of the total. Figure 2.1 reveals the distribution of major land use in Nepal for the year 1978/79.

Distribution of land use by physiographic region is presented in table 2.3. This distribution of the physiographic region is based on the location of the districts. District category as per broad physiographic of the districts is given in annex 2.

Figure 2.1: Land use distribution in 1978/79

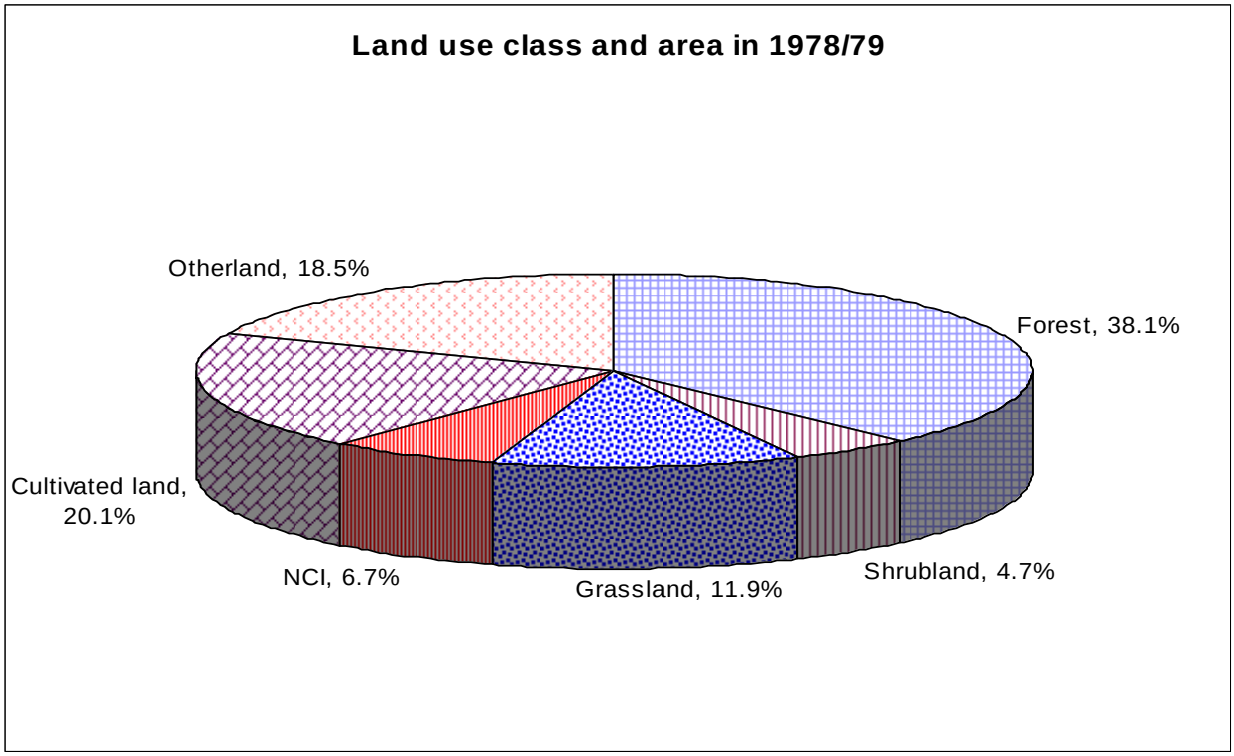


Table 2.3 : Distribution of land use by physiographic region in 1978/79

Landuse type	District_category			Grand Total
	Mnt district	Hillly district	Terai district	
Forest	8.6%	18.9%	10.6%	38.1%
Shrubland	1.5%	2.9%	0.3%	4.7%
Grassland	7.7%	3.7%	0.5%	11.9%
NCI	1.0%	4.6%	1.1%	6.7%
Cultivated land	1.9%	8.7%	9.6%	20.1%
Otherland	14.5%	3.0%	1.1%	18.5%
Grand Total	35.2%	41.7%	23.1%	100.0%

Source: WECS (1988)

The regional distribution of accessibility by land use in presented in annex 2. From fuelwood production perspective, all type of land use except other land category are important source because forest, trees and woody resources are either found in natural state or grown in those land categories. Table 2.4 shows percentage distribution of all land use category by gross and accessible area. Only about 55% of the land was found accessible in total land use.

Figure 2.2 : Distribution of land use by gross and accessible area (1978/79)

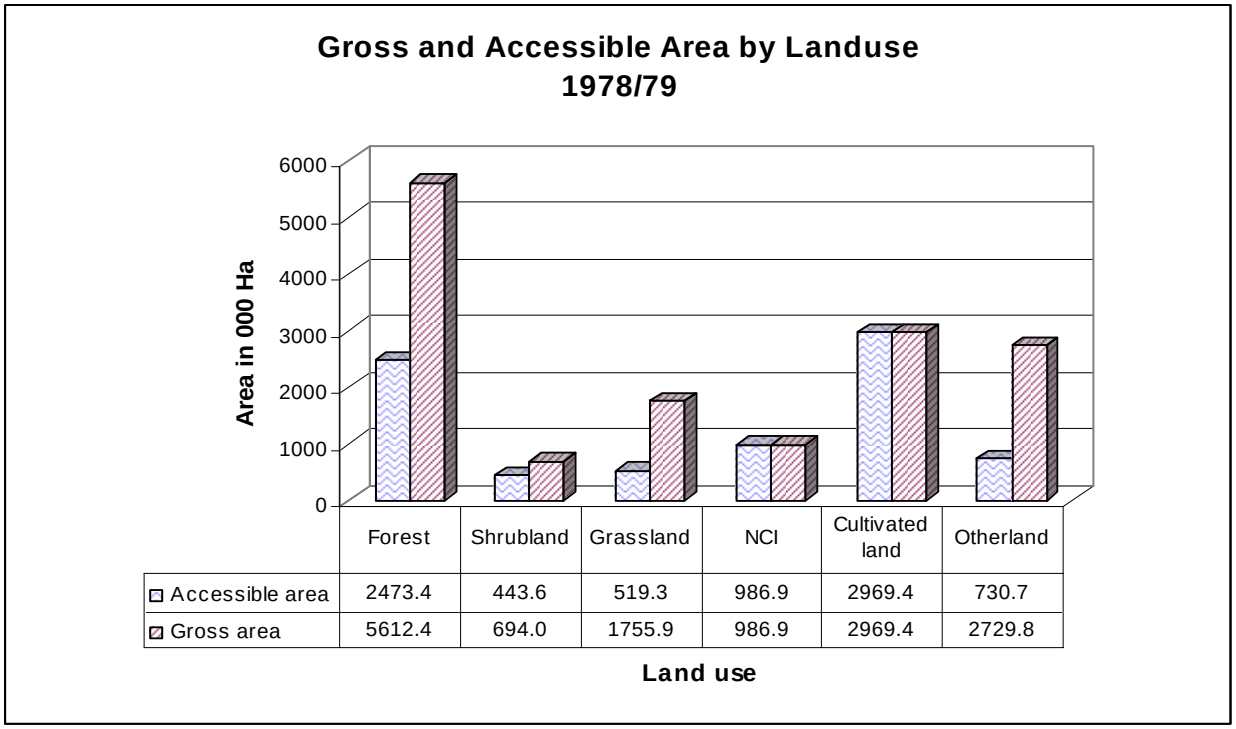


Table 2.4: Percentage distribution of accessible land use (1978/79)

Land use type	Development Regions					Grand Total
	EDR	CDR	WDR	MWDR	FWDR	
Forest	48.0%	44.4%	51.8%	35.8%	46.4%	44.1%
Shrubland	33.5%	82.0%	72.2%	61.7%	77.9%	63.9%
Grassland	41.1%	39.2%	21.5%	23.6%	51.9%	29.6%
NCI	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Cultivated land	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Other land	36.6%	48.6%	27.1%	15.4%	37.8%	26.8%
Grand Total	64.3%	68.4%	56.5%	38.1%	57.9%	55.1%

Source: WECS (1988)

Physiographic regions here represent the actual geographical position of the land surface irrespective of district location. For example, Chitwan district is located both the Terai and Hills. Similary, Gorkha district has a geography of hills and mountain.

Table 2.5: Distribution of Forest land by development and physiographic region (1978/79)

Development Region	Phy region			Grand Total
	Terai	Hills	Mountain	
EDR	1.2%	9.6%	6.1%	16.9%
CDR	2.2%	13.5%	4.0%	19.7%
WDR	1.4%	9.6%	5.4%	16.5%
MWDR	2.2%	14.6%	12.5%	29.3%
FWDR	3.5%	9.9%	4.3%	17.6%
Grand Total	10.5%	57.3%	32.3%	100.0%

Source: WECS (1988)

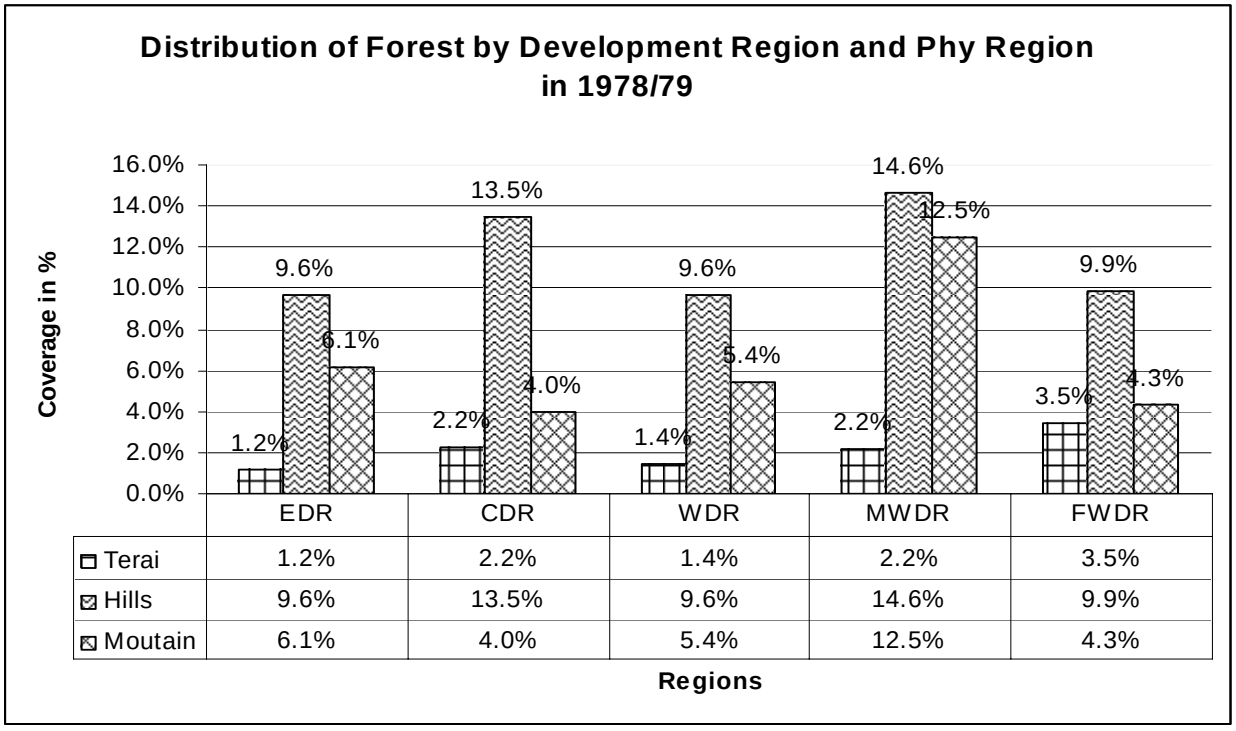
Table 2.6 shows the distribution pattern of forest land as per the general physiography of the districts. All the 20 terai districts were classified into Terai region. Similary, 16 districts of the northern Nepal are classified into Mountain region. Remaining 49 districts were grouped into Hilly region.

Table 2.6: Distribution of Forests by Dev Region and Phy Belt (1978/79)

Development Region	District category			Grand Total
	Terai district	Hilly district	Mnt district	
EDR	2.7%	8.6%	5.6%	16.9%
CDR	6.9%	9.1%	3.7%	19.7%
WDR	3.8%	12.1%	0.5%	16.5%
MWDR	8.4%	13.0%	8.0%	29.3%
FWDR	5.9%	6.9%	4.8%	17.6%
Grand Total	27.7%	49.8%	22.5%	100.0%

Source: WECS (1988)

Figure 2.3: Distribution of Forests by Development Region and Physiographic Region



Accessibility of forest land by development and phy region in 1978/79 is presented in annex 2.

2.1.1.5 Forest Resources in 1980s

MPFS (1988) has estimated the forest area coverage of Nepal for the year 1985/86 at regional and national level based on the LRMP findings, WECS estimates and deforestation rate of the 1964/65 to 1978/79 period. Table 2.7 shows the distribution of land use by development and physiographic region in 1985/86.

Table 2.7: Distribution of Land Use by Dev. Region (1985/86)

Unit in 000 ha.

Region	Landuse type						Grand Total
	Cultivated land	NCI	Grassland	Forest	Shrubland	Otherland	
FWDR	302	113	212	991	52	274	1944
MWDR	465	178	783	1641	76	1138	4281
WDR	608	229	437	900	142	619	2935
CDR	818	239	138	1063	238	238	2734
EDR	859	239	175	923	198	460	2854
Grand Total	3052	998	1745	5518	706	2729	14748

Source: MPFS (1988a)

The forest of Nepal was estimated to be 5.5 million ha or 37.4% of the total area of the country. Figure 2.4 shows the distribution of forests by physiographic region.

Figure 2.4: Distribution of Forests by Physiographic Region (1985/86)

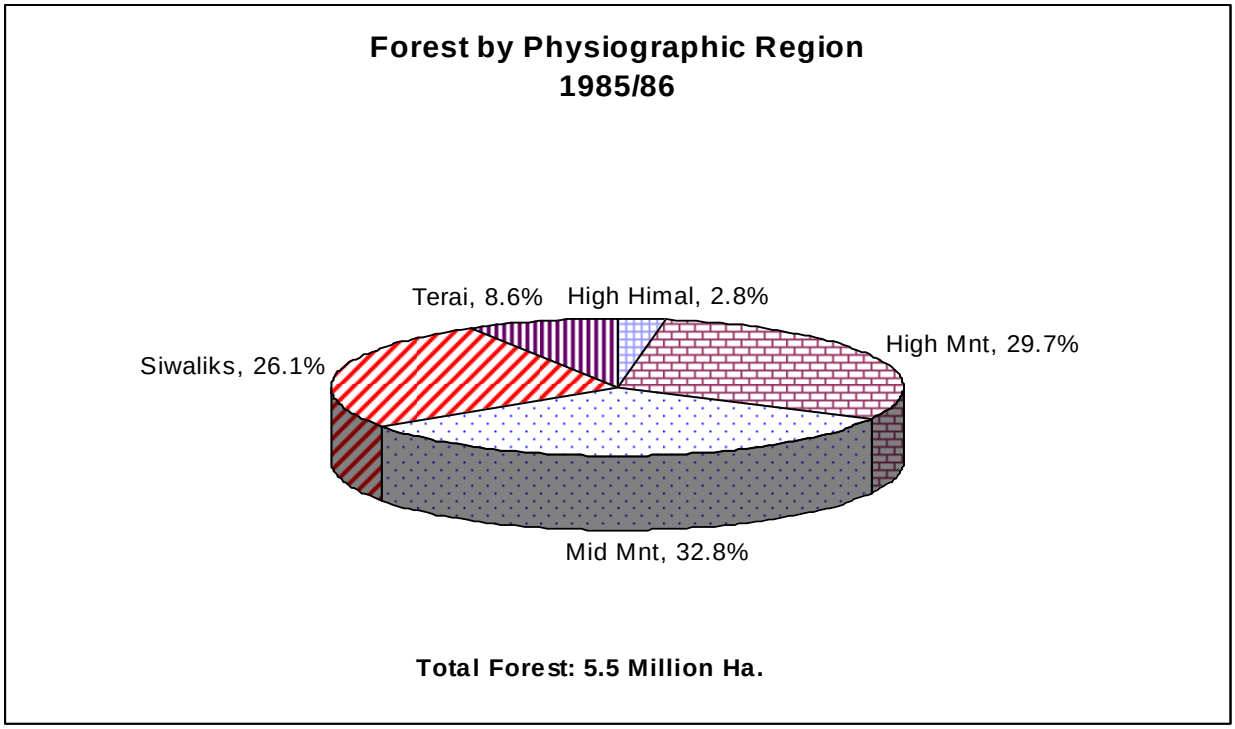


Table 2.8: Land use by physiographic region (1985/86)

Unit in 000 ha.

Physiographic Region	Landuse type						Grand Total
	Cultivated land	NCI	Grassland	Forest	Shrubland	Otherland	
High Himal	8	1	885	155	67	2234	3350
High Mnt	244	148	508	1639	176	245	2960
Mid Mnt	1223	667	278	1811	404	59	4442
Siwaliks	269	59	16	1438	29	75	1886
Terai	1308	123	58	475	30	116	2110
Grand Total	3052	998	1745	5518	706	2729	14748

Source: MPFS (1988a)

2.1.1.6 Forest Resources in 1990s

The Department of Forest Research and Survey with the support from FINNISH has completed another assessment of forest resources both in area and stock perspective. It took about 11 years to complete starting from 1987 and national report was published in 1999. During this assessment both the aerial photograph and satellite images were analyzed to estimate the forest and shrub coverage. Field work was carried out to verify the aerial photos and satellite image work. Inventory of the forest sample field were taken during this period. Summary of the forest inventory results of this period is presented in table 2.9

Table 2.9: Forest Inventory of Nepal (1987-1998)

Region	Total land (area in ha)	Total Forest (area in ha)	Forest as percent of total land (%)	Total shrub land (area in ha)	Shrub land as percent of total land (%)	Total percent of forest and shrub land (%)
FWDR	1,953,900	687,400	35.2	263,9000	13.5	48.7
MWDR	4,234,800	1,192,400	28.2	442,000	10.4	38.6
WDR	2,939,800	734,300	25.0	256,900	8.7	33.7
CDR	2,741,000	918,600	33.5	233,800	8.5	42.0
EDR	2,845,600	736,100	25.9	362,600	12.7	38.6
Total	14,718,100	4,268,800	29.0	1,559,200	10.6	39.6

Source: DFRS/FRISP (1999)

Besides forests and shrubland, rest of the land use such as grassland, cultivated land, public open land, degraded land other land categories also have trees and forests with different intensity. Initially, the LRMP/WECS fuel-wood supply study in 1987 had applied a maximum access distance of 4 km measured horizontally from the supply source as a consideration for accessibility of the existing forests and shrub lands in the hills and mountains, except in the Terai plain where all forests and shrub lands were assumed accessible, for meeting both local needs as well as for commercial supply of forest products. This accessibility model of forest and shrub land sub-classification system was also followed in MPFS (1987) for assessing the sustainable production potentials of forest products from forests and shrub lands, for meeting both local needs as well as for commercial supply of forest products.

Later assessment of the forest resources of Nepal, by DFRS/FRISP in 1999, has changed the LRMP/WECS (1987) adopted accessibility based sub-classification model which was also used by FSMP (1987) with introduction of a new sub-classification criterion that is based on reachable or non-reachable characteristics of forests and shrub lands. According to these considerations any forest area (including shrub land) that is located on a slope of more than 100 percent (or 45 degrees), or is surrounded by steep slope, landslides or other physical obstacles or protected areas is considered non-reachable for the supply of forest products, including fuel-wood. The current area of reachable area is about 51.5 percent (DFRS/FRISP, 1999).

This reachable forest area is important in terms of assessing the sustainable wood supply in the country. Reachable forest area by altitude classes and Development regions is given in annex 2. Due to change of concept, forest area that is now considered reachable has increased from 43% 1978 to 51% in 1999, and the area of reachable shrubland has now decreased from 64% to 52% (DFRS/FRISP, 1999).

2.1.1.7 Forest Resources in the 2000s

FAO has been carrying out Global Forest Resource Assessment in its member countries at every five years interval. Table 2.10 provides forest cover statistics of Nepal, which has been reported to FAO in the course of preparing country report on Global Forest Resource Assessment 2000 and 2005. The result is provided in table 2.10.

Table 2.10: Estimation of Forests and Shubland in FAO Reports

Cover type	Unit	Year	
		2000	2005
Forest	Area (000ha)	3900	3636
	Percentage	26.5%	24.7%
Shrub	Area (000ha)	1753	1897
	Percentage	11.9%	12.9%
Total	Area (000ha)	5653	5533
	Percentage	38.4%	37.6%

Source: *FAO, 2001; **FAO 2006

Both studies were based on the assumption of DFRS (1999) report. However, findings of the 2005 study work was little different than the 2000. In 2005 study, 25% of the forest lost area is assumed to be converted into shrubland and similar situation was adopted for the shrubland. About 4.2 million hectares of forest and 1.5 million hectares of shrubland were assessed for the middle time of the survey period that is 1994/95.

2.1.1.8 Terai Forest Assessment (1991-2001)

The recent study shows that forest in the twenty Terai districts including protected areas cover around 1.39 million hectares (DoF, 2005). The productive forests in these regions have a significant role not only in the economic development of the country, but also in sustaining rural livelihoods. Table 2.11 provides information on forest statistics of 20 Terai districts.

The study report presented the changes in forest cover between the period 1990/91 and 2000/01 in 20 Tarai districts of the country. These districts bordered India in the south and embraced both plain and hilly parts corresponding to their respective administrative division. This study, however, did not distinguish the forest from shrubland areas. Instead, both forest and forest (or shrubland with less than 10% crown cover) were grouped under a common heading of forest cover, which excluded the areas under protection (i.e. national parks, wildlife reserves, or other categories gazetted under the National Park and Wildlife Conservation Act of 1973).

Table 2.11: Terai Forests Resources (1990/91-2000/01)

Year	Forest & Shrub
	Unit in 000 ha
1990/91	1398.912
2000/01	1390.091
Total change	-8.821
Change/year	-0.8821
Percentage change/year	-0.06%

Source: DoF (2005).

2.1.1.9 Community Forests

Community forest has covered more than one forth of the total national forests in Nepal. It is the second largest management regime after the government managed forests. Table 2.12 shows the community forest land by physiographic and development region in Nepal

Table 2.12: CF area by development region and physiographic region (2010)

Unit in 000 ha

Development Region	Physiographic Region			Grand Total
	Terai	Hills	Mountain	
FWDR	15.3	104.3	64.0	183.6
MWDR	82.1	139.7	44.7	266.6
WDR	12.2	165.3	6.7	184.2
CDR	24.4	181.9	56.1	262.4
EDR	35.6	240.5	56.8	332.9
Grand Total	169.5	831.7	228.4	1229.7

Sources: FECOFUN (2010).

By development region, Eastern Region is the largest one in terms of area of community forest followed by MWDR, CDR, WDR and FWDR. Figure 2.5 shows the proportion of community forest number and area by development region. Distribution of the community forests is very disproportional as shown in table 2.12. WDR is richest in terms of number having 26% of the total CF. However, EDR is rich in terms of area because it occupies about 27% of the total CF area. This simply indicates that CF are very dissimilar in area term.

Figure 2.5: Distribution of CF by Development Region and Physiographic Region

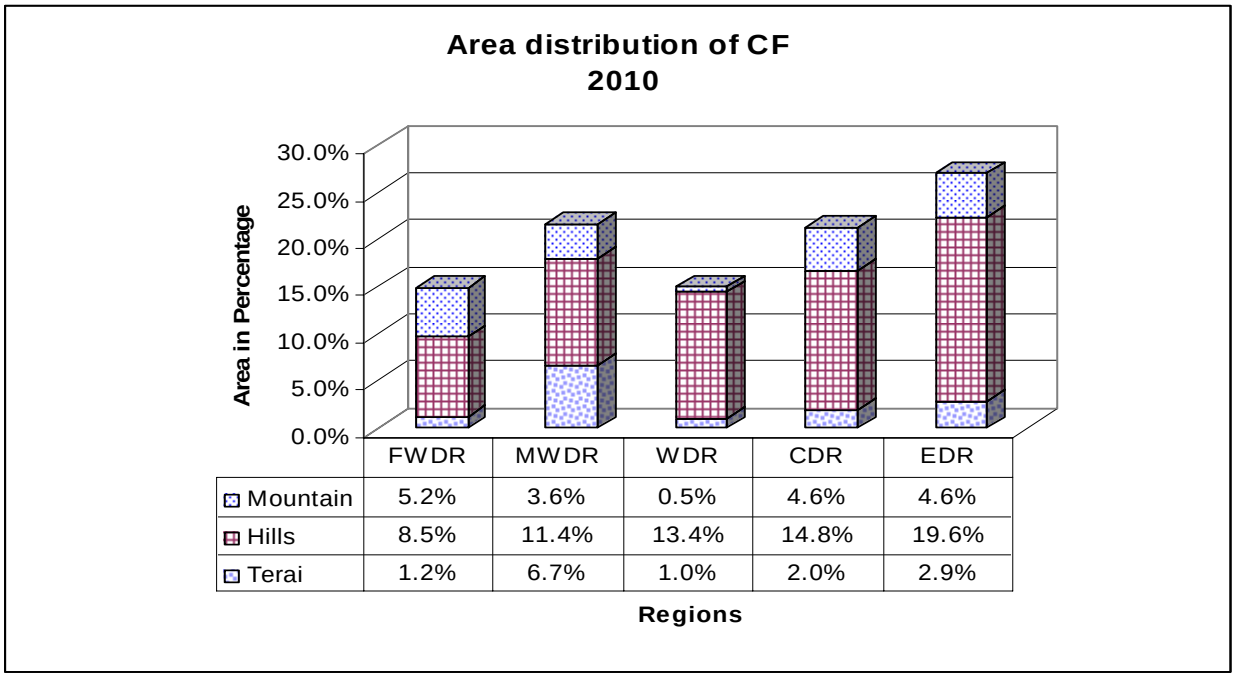
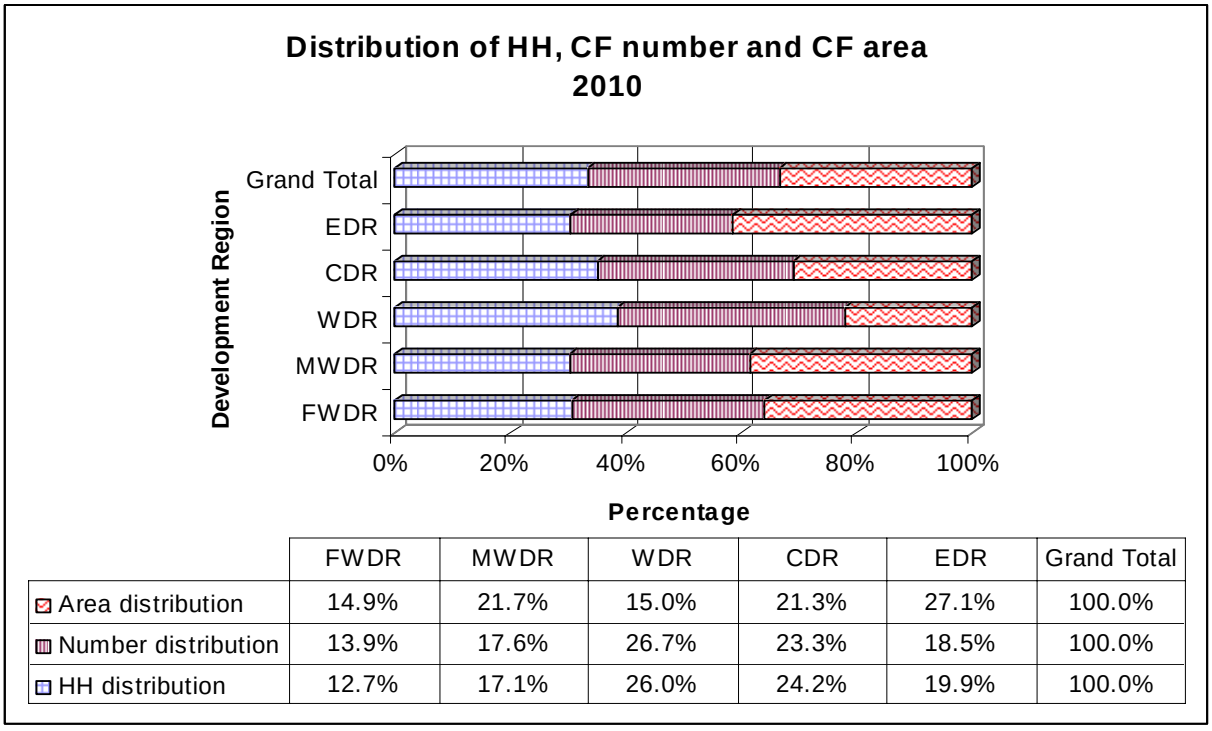


Figure 2.6 shows the distribution pattern of household number, CF number and CF area by development region and physiographic region. While looking at the development region, WDR is proportional in terms of HH and CF numbers whereas area is quite less as compared to household number. The situation is completely opposite for EDR because it has larger area of CF for small number of household.

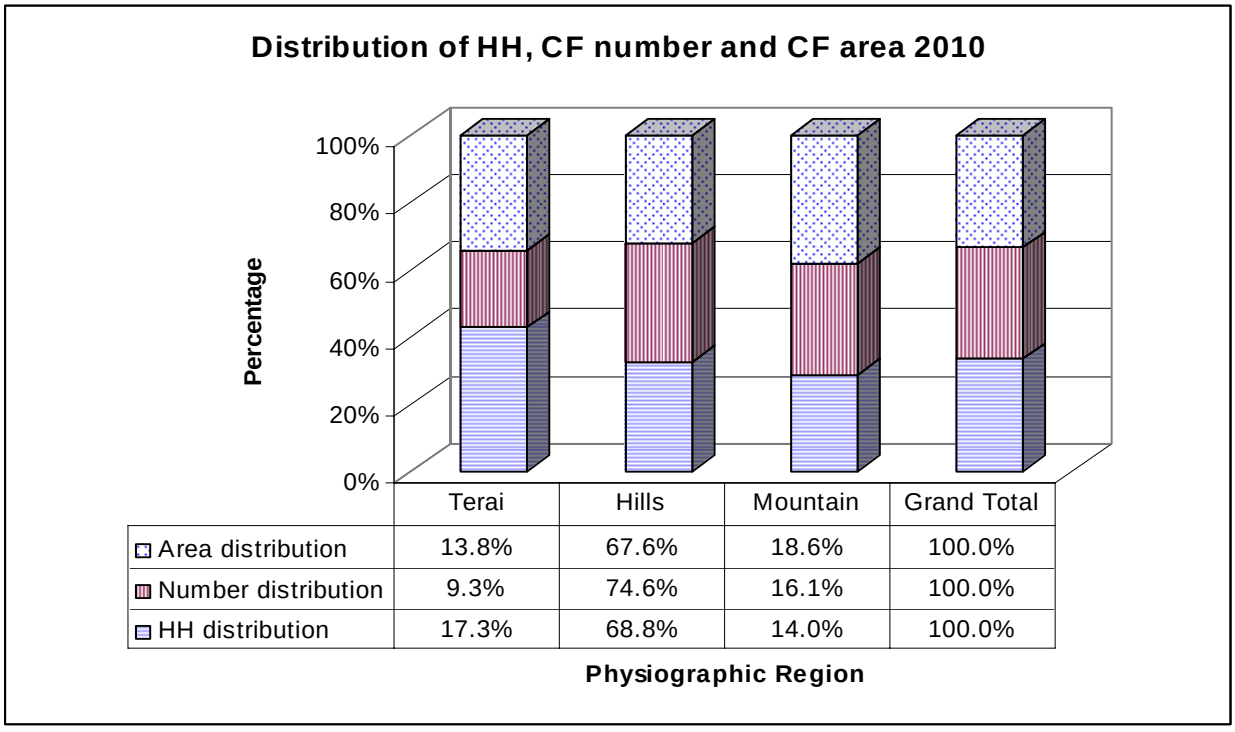
Figure 2.6: Distribution of HH, CF number and CF area



	FWDR	MWDR	WDR	CDR	EDR	Grand Total
Area distribution	14.9%	21.7%	15.0%	21.3%	27.1%	100.0%
Number distribution	13.9%	17.6%	26.7%	23.3%	18.5%	100.0%
HH distribution	12.7%	17.1%	26.0%	24.2%	19.9%	100.0%

Similarly, distribution of HH, CF number and CF area by physiographic region is presented in figure 2.7.

Figure 2.7: Distribution of HH, CF number and CF area



	Terai	Hills	Mountain	Grand Total
Area distribution	13.8%	67.6%	18.6%	100.0%
Number distribution	9.3%	74.6%	16.1%	100.0%
HH distribution	17.3%	68.8%	14.0%	100.0%

Source: Derived from FECOFUN (2010)

2.1.1.10 Deforestation and Degradation of the Forests

Figure 2.8 shows the forest cover change in selected countries of the Asia. The highest deforestation rate exists in Nepal followed by Pakistan and Sri Lanka respectively. Forest land was increasing by about 2.2% and 1.2% annually during 2000-2005 and 1990-2000 period in China.

Figure 2.8: Forest Cover Changes in Selected Asian Countries

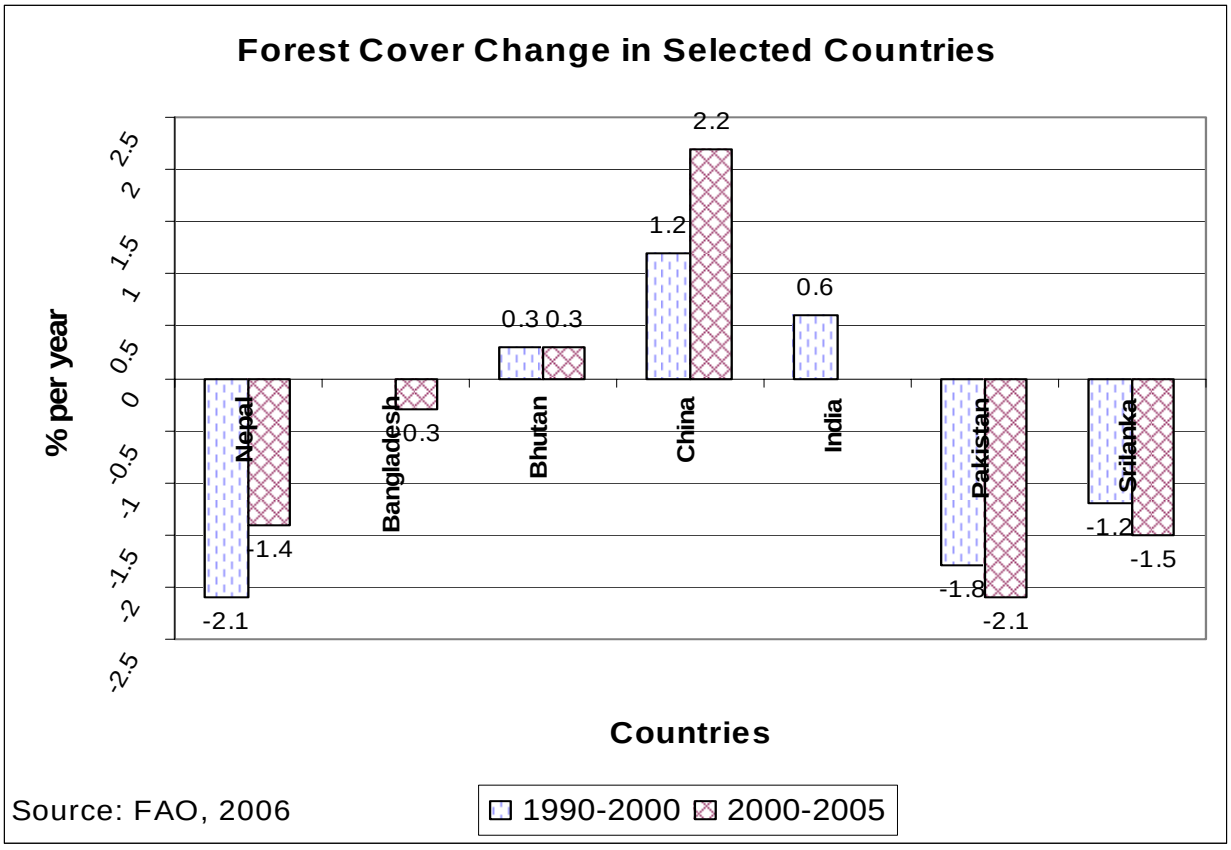
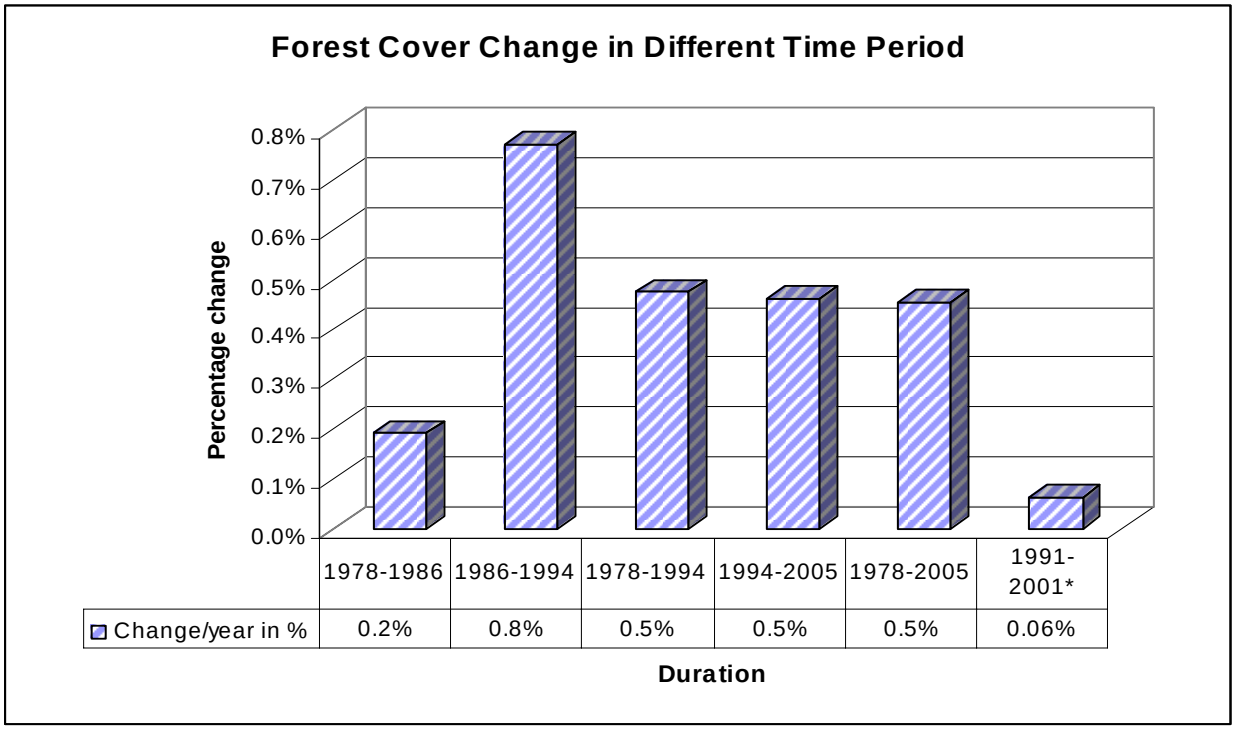


Figure 2.9 provides information on forest cover change per year in Nepal in different time series. The highest rate of change was during 1986-1994 and the lowest in 1991-2001. However, the forest cover change during 1991-2001 covers only the data of 20 Terai Districts of Nepal. The changed forest cover statistics include both areas, forests (with over 10% crown cover) and shrublands (with less than 10% crown cover). Therefore, a new data for reachable forest and reachable shrublands would be necessary to compiled with incorporation of the changes recorded in DoF (2005), at both district and development region levels. The data for other 55 districts would however remain unchanged as there has been no new effort after the DFRS/FRISP study, reported in 1999.

The annual rate of change in forest cover for the studied period was noticed negative in virtually all districts located in the plains, but the trend was slightly positive in districts which also comprised of some hilly areas (i.e. Dang, Nawalparasi, etc). It was also reported that the rate of forest cover change was generally higher in the plain than in hilly areas of specific district. At

the aggregate level the rate of forest cover change was reported positive (0.06 percent) in hilly areas compared to a negative change (-0.27 percent) in the plains in past ten years.

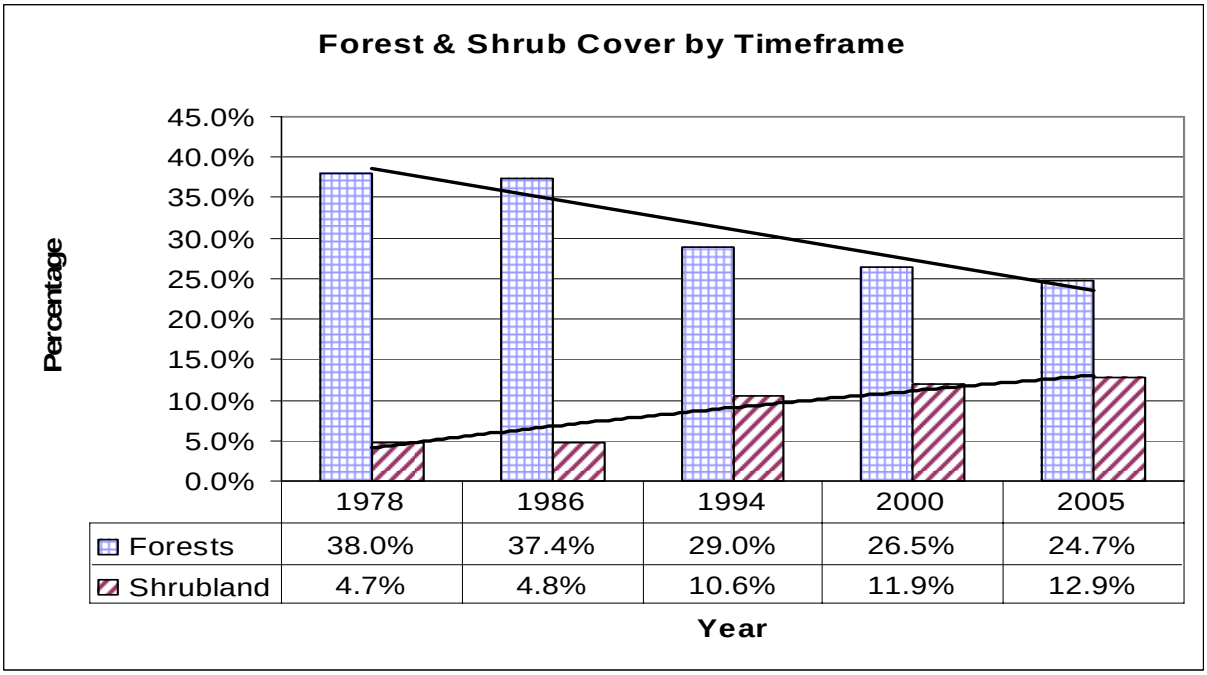
Figure 2.9: Forest Cover Change in Nepal



Although this study showed the rate of change in forest cover in past ten years but it did not analyzed the change in forest quality (stocking and crown cover), which posed as a limitation to assess the actual growing stock in these districts. Therefore the growing stock information for these districts still depended on the statistics available from DFRS (1999). However, some adjustment would be necessary to incorporate the loss in growing stock as per the change in forest cover in these districts. As no study was conducted lately to assess the rate of change in forest cover in other fifty five districts, all in the hills and mountains, the information regarding reachable forest area and standing stock would remain unchanged from DFRS (1999) findings.

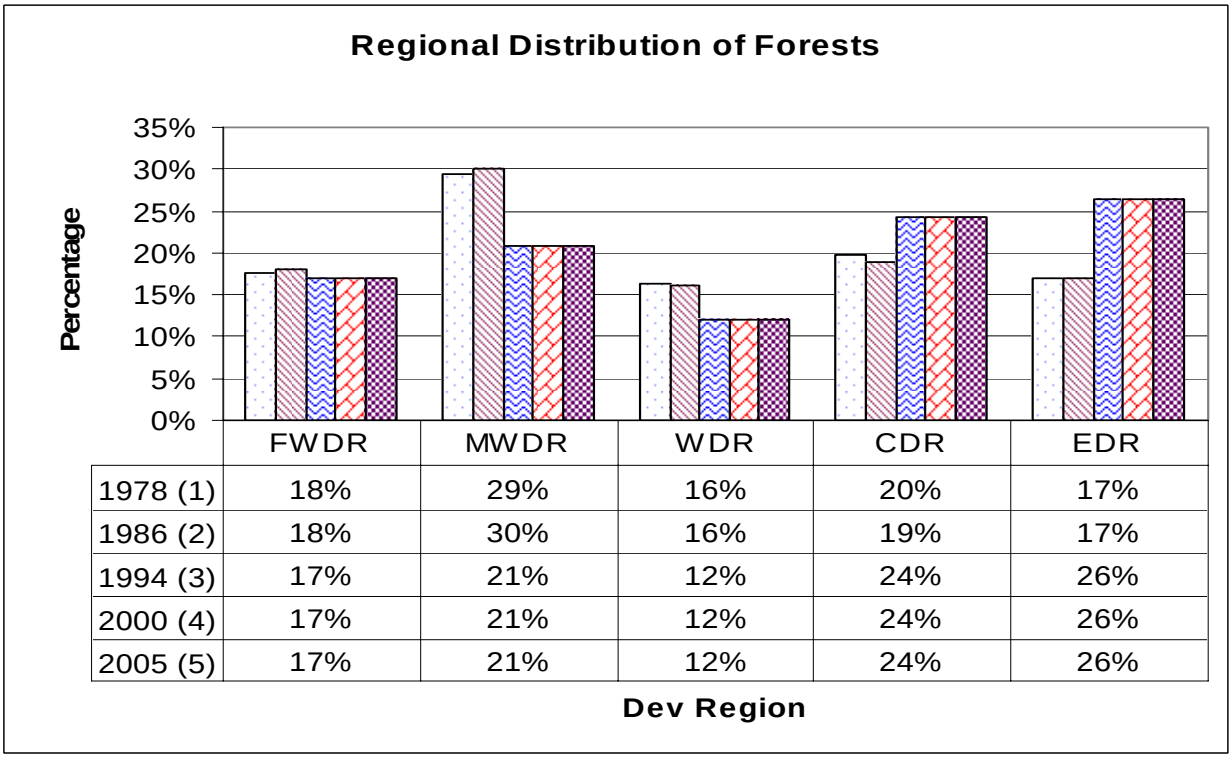
Figure 2.10 shows the changes in forest and shrubland during 1978/79 to 2005. Forest and shrub cover in 1978/79 was about 42% which reduced to a level of 37% in 2005 with an annual deforestation rate of 0.5%.

Figure 2.10: Changes in Forests and Shrubland in Nepal



2.1.1.11 Regional Distribution of Forest over Time Duration

Figure 2.11: Regional Distribution of Forests by Time Series



Source:(1): MPFS (1988), (2): MPFS (1988), (3): DFRS (1999). (4) & (5): assumed to be equal to the year of 1994

2.1.1.12 Forest Growing Stock in Nepal

The term Growing Stock refers the total wood volume available in a forest land. Once the wood volume is known, biomass can also be estimated using the density factor of the species of concern. It is essential to understand the dynamics of forest stand, their productive capacity and to manage their use within limits of sustainability defined by their dynamics of growth. Table 2.13 exhibits the growing stock of natural forests land in different time period.

Table 2.13: Growing stock distribution in different time series (in cubic metre/ha)

	Year					
Development Regions	1964*	1978**	1986**	1994*	2000***	2005***
FWDR	94.0	104.1	104.0	150.0	NA	NA
MWDR	88.0	125.6	125.0	113.0	NA	NA
WDR	71.0	73.5	72.0	117.0	NA	NA
CDR	77.0	82.8	83.0	122.0	NA	NA
EDR	96.0	71.6	71.0	147.0	NA	NA
Average	85.0	91.5	91.0	131.0	96.0	96.0

Sources: *DFRS, 1999; ** MPFS (1988) ; *** Assumed to be equal to the year of 1986

Regarding the growing stock, the first inventory on a national level took place in the 1960s. Inventory results were presented for the Terai and adjoining regions in 1967 and for the Hills in 1973. The latest national forest inventory was completed in 1994 and report was published in 1999. The mean stem volume up to 10 cm top are 85 and 131 cubic metre/ha in 1960s and 1994 respectively (Table 2.13). Comparing the mean growing stock figures of two inventory results, it was found 46 cubic metre/ha more in 1994 than that of 1960s. Including tops and branches, which are usable for firewood, total volume is estimated to be 3390 cu.ft per hectare for the Terai and Siwaliks, and 2408 cu.ft per hectare for the Hills.

Based on the NFI results of 1994, Far-western Development Region has the highest mean stem volume (150 cubic metre/ha) and Mid-western Development Region has the lowest (113 cubic metre/ha). The growing stock figures according to physiographic regions are available for the year 1986 only. In the year 1986, high himal has the highest mean stem volume (155 cubic metre/ha) and mid-mountain has the lowest (59 cubic metre/ha).

In 1994/95, total stem volume (over bark) of reachable forests of Nepal was 388 million cubic metres and the total biomass of stems, branches and leaves is 429 million tonnes (air dry). For the whole country, the projection of total volume and biomass is estimated at 759 million cubic metre and 873 million tonnes respectively. The mean stem volume (over bark) of Nepal is 178 cubic metre/ha, the mean stem volume up to 10 cm top is 131 cubic metre/ha and the average number of stems per hectare is 408 (DFRS, 1999). Total growing stock of forests in Nepal are presented in Table 2.15.

Table 2.15: Total growing stock of forests in Nepal (in million cubic metre)

Development Regions	Years		
	1978	1986	1994*
FWDR	103.0	102.0	71.9
MWDR	206.9	204.0	71.1

WDR	67.9	64.0	43.8
CDR	91.5	85.0	89.8
EDR	67.9	64.0	110.9
Total	537.2	519.0	387.5

Note: * = Total growing stock of reachable forest only
Sources: MPFS (1988); DFRS (1999); WECS (1988)

Figure 2.12: Growing Stock by Years and Forest Types in Nepal

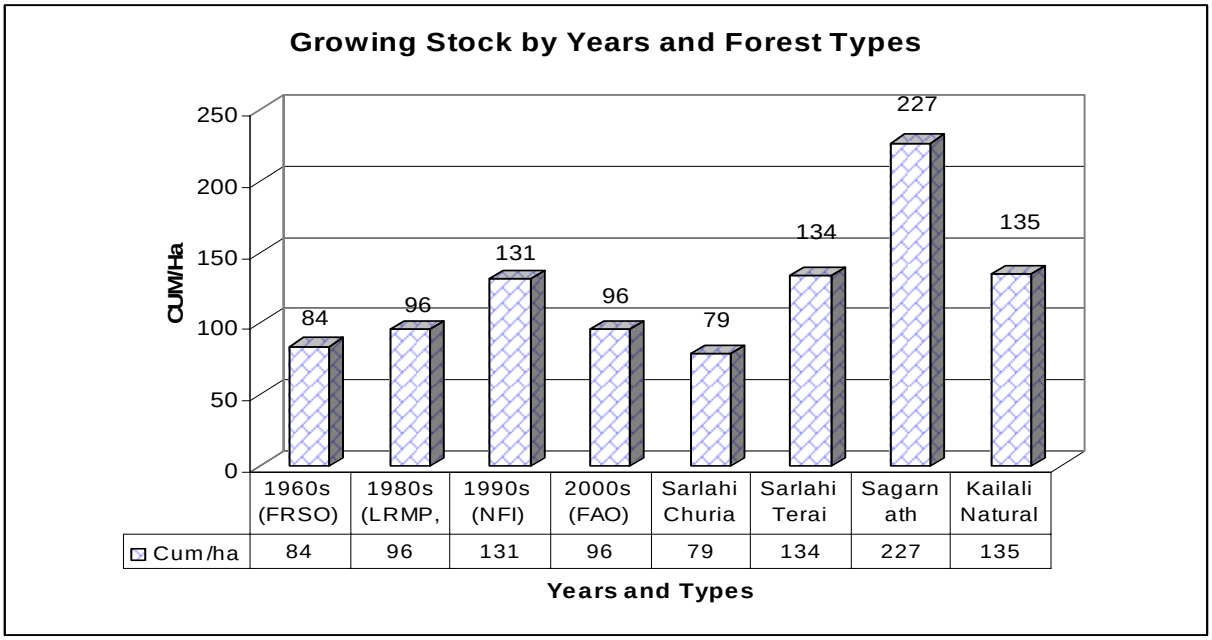
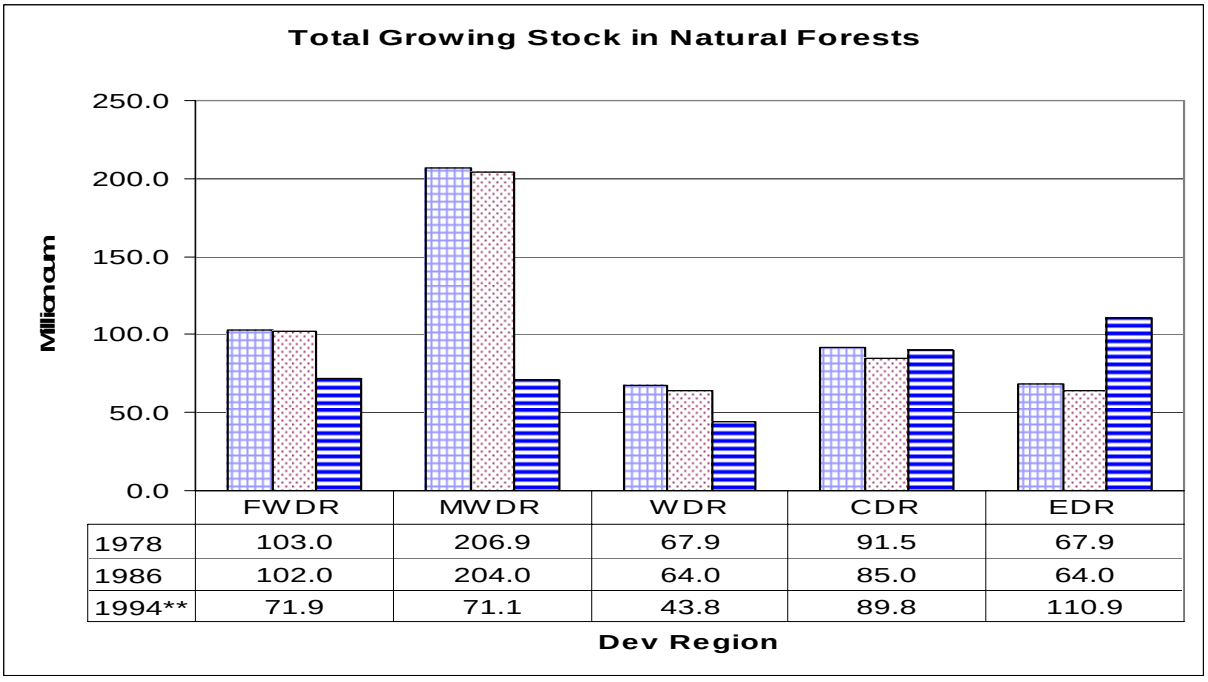


Figure 2.13: Total Growing Stock in Natural Forests in Nepal



2.1.1.13 Sustainable Wood and Fuelwood Production

The different types of national forests, together with government owned tree plantations established on national forest lands are the main supply sources of direct woodfuels. These forests are governed with specific legislative arrangements under the broad framework of Forest Act 1993 and Forest Rule 1995. These sources are important for supplying the wood, woodfuels and other forest products to local communities for self-use, as well as some for trade in commercial markets. But these resources are not distributed equitably to meet the total forest products needs of the people in every part of the country.

Assessment of wood and fuelwood production potential of the existing forest resources in the country was initiated in early 1960's, after establishment of the Forest Resources Survey Office (FRSO) of the Department of Forest (DoF) under the financial and technical assistance of USAID-Nepal in 1963. The aerial photographs taken during 1953-1958, 1962, and 1967 were used to prepare a land use map showing different land use categories: Forest, Cropland, Grass, Urban, Water, Badly eroded and Barren. The Forest was further divided into the noncommercial forest and the commercial forest.

The noncommercial forest was further divided into four categories and the commercial forest into six category, two stand-size and three density-classes. The strip photographs taken during 1964-65 were used to rectify the preliminary estimate of area. However, not all areas in the country could be traversed at fixed intervals for aerial photography, because some northern areas were classified as sensitive and restricted for taking aerial photographs. The Forest Survey and Research Office (FSRO) analyzed and interpreted the information and published four reports in a series providing the forest statistics of Nepal. The first report was published in 1965 that provided the forest statistics of Chitwan valley, the second report of 1967 covered the Tarai and adjoining regions, the third report of 1969 dealt with the Bheri-Karnali area, and the last report of 1973 was concerned with the hill region (FRSO, 1973).

MFSC (1987) states that FSRO conducted several forest inventories over the past two decades in connection with the preparation of forest working/management plans. Three inventories had extensively analyzed the data of the Tarai and mountain areas, their plot data provided mainly the stem volume data and not total tree/ forest biomass that has energy potential. It was of the view that the Land Resources Mapping Project (LRMP) had used similar definitions for forest types, crown cover, and tree size categories as of FSRO, so the existing forest inventory data from two decades ago could still be combined with LRMP defined forest types and hecterage information for estimating the stand volume in 1979.

LRMP had classified the major species types in Nepal as Conifers, Hardwoods, Mixed Forests, and Broad type, which either comprised of Conifers, Hardwoods or Mixed Forests. For master planning purposes in the forestry sector, the FSRO classification of commercial and non-commercial forests were considered irrelevant, as other factors, accessibility and capacity to support commercial forestry venture, could both influence and define the commercial potential of a forest stand than productivity alone.

The species composition for each defined forest type was assumed to calculate biomass ratios, for Sal forest type, the species composition assumed was 90 percent Sal and 10 percent other

species. These percentages were used as weights in calculating composite biomass ratios out of the biomass ratios for Sal and the species representing the other species in a Sal forest type. A similar procedure of assuming species composition was followed to arrive at a composite wood density for each forest type. Forest types, representative species, uses, and wood density that were adopted during forestry master planning exercise, having relevance to woodfuel production, has been provided in MFSC (1987).

Making accurate estimates of fuelwood supply and demand is very difficult task. There are many variables, both physical and socio economical. The amount of wood producing land is very difficult to estimate. The productity of the land varies a great deal. Consumption is also different in different parts of the country and is difficult to measure. Table 2.16 provides the sustainable fuelwood supply information by land sue and development region in the year 1978/79.

Table 2.16: Sustainable Fuelwood Supply from Accessible Land Areas (1978/79)

Unit in 000 MT

Land use	Regions					Total
	FWDR	MWDR	WDR	CDR	EDR	
Forests	1035	1082.2	1014.1	1203.6	902.5	5237.6
Shrubland	32.6	34.5	68.5	126.2	52.6	314.5
Grassland	11.2	18.5	9.4	6.1	7.3	52.5
NCI	31.5	54.9	71.5	71.2	66.5	295.6
Cultivated land	127.2	192.7	244.8	260.8	308.3	1133.8
Total	1237.5	1382.8	1408.3	1667.9	1337.2	7034.0

Sources: WECS (1987)

In the LRMP data, the non cultivated inclusion areas (NCI) are the areas which were too small to map at a scale of 1:50,000. NCI area includes forests, shrubs and other land use. In order to estimate a supply of fuelwood from these areas the yield per hectare used for shrub land (i.e, 0.69 tons/ha/year) is used for both the forest and shrub. WECS (1987) has made a detail study regarding the assessment of sustainable fuelwood supply in Nepal. Figure 2.14 shows the sustainable fuelwood supply from accessible land of physiographic regions.

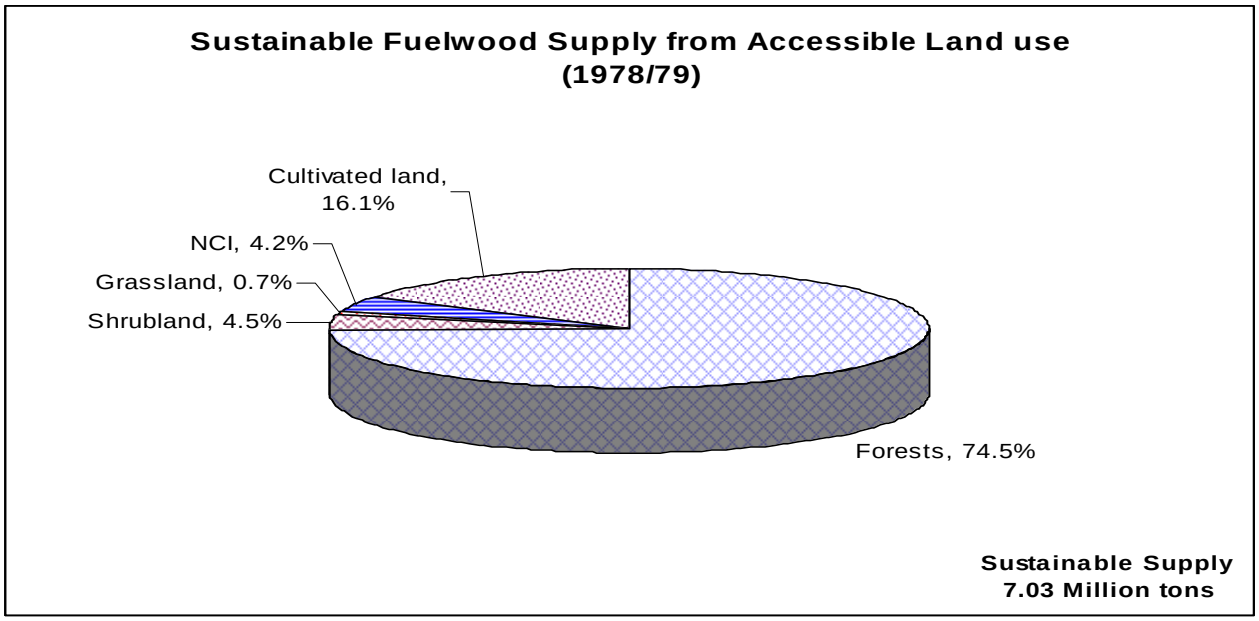


Figure 2.14: Contribution of Land use in Sustainable Fuelwood Production (1978/79)

2.1.1.14 Volume and Yield

Based on the 1964 Nepal Forest Inventory, the estimated annual yields are 78.51 cu. ft per hectare and 45.9 cu.ft per hectare (i.e., 2.3% and 1.9%) respectively of total volume for forests in the Terai/Siwaliks and Hills. In 1984, the Land Resources Mapping Project (LRMP), as parts of its land use survey, began development of a method to estimate accessible areas. This work has been continued by WECS and also Ministry of Forests and Soil Conservation. The yield of fuelwood per hectare at 100% crown cover (air dry tones) is given below.

Table 2.17: Sustainable Fuelwood Production (tons/ha/year) in 1978/79

Types	Yields (tons/ha/year)	Remarks
Hardwood Forest	5.00	Assuming 100% crown cover and product with air dry matter
Coniferous Forest	1.25	
Mixed Forest	3.75	
Shrub land	1.25	
Grass land	0.10	

Source: WECS (1987)

For fuelwood supply estimate, shrubland is assumed to be 55% of the crown cover. Therefore actual yield becomes 0.69 tons/ha/year. Sustainble Fuelwood supply from different land use categories by development regions is presented in table 2.16 Yields from the forest, shrubland, grassland and NCI land are estimated based on the unmanaged land categories.

Figure 2.15: Sustainable Fuelwood Production by Development Region (1978/79)

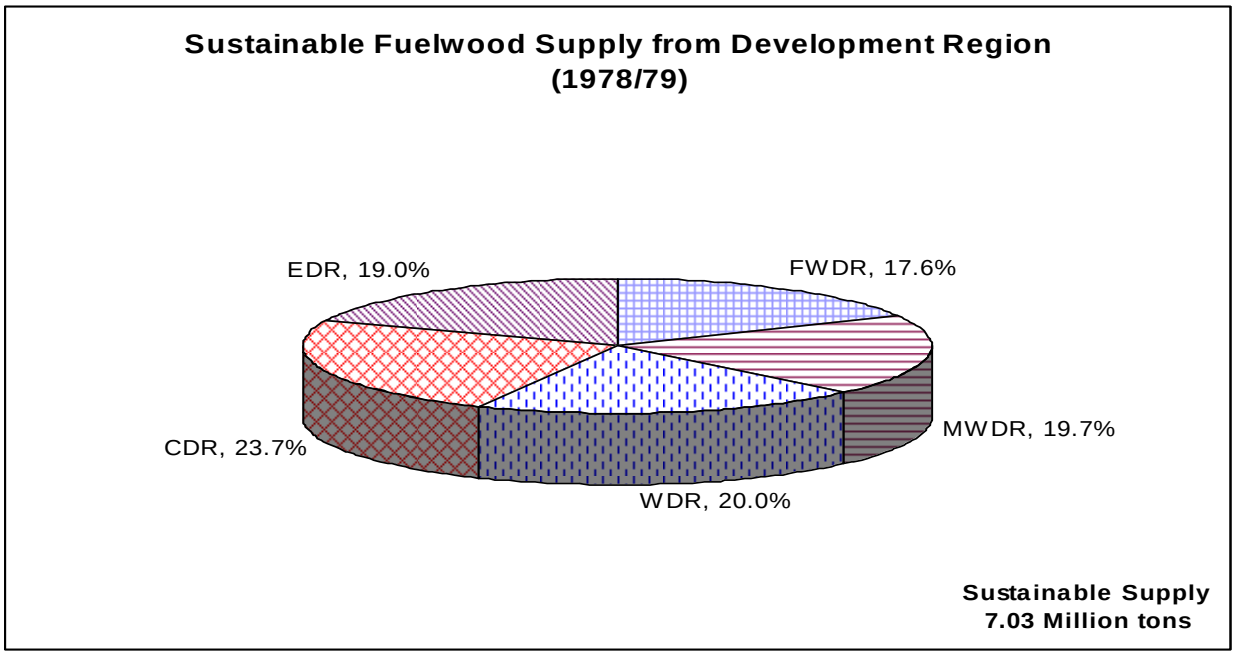


Figure 2.16: Sustainable Fuelwood Supply by Physiographic Region

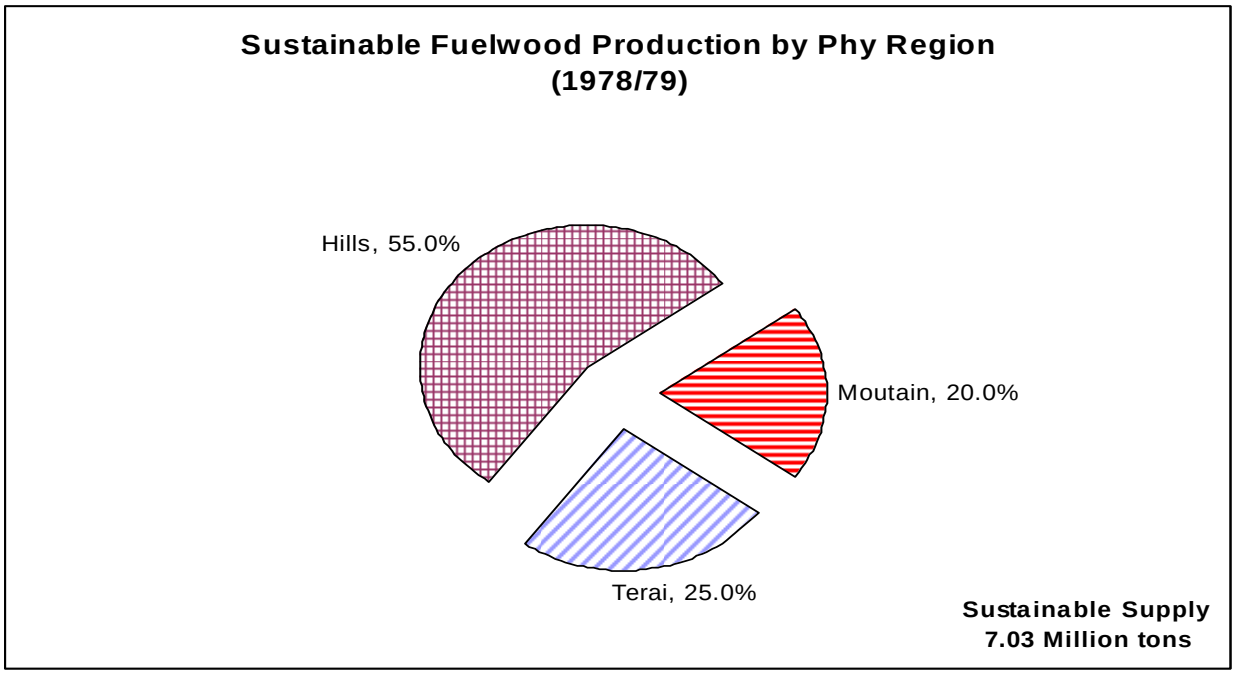
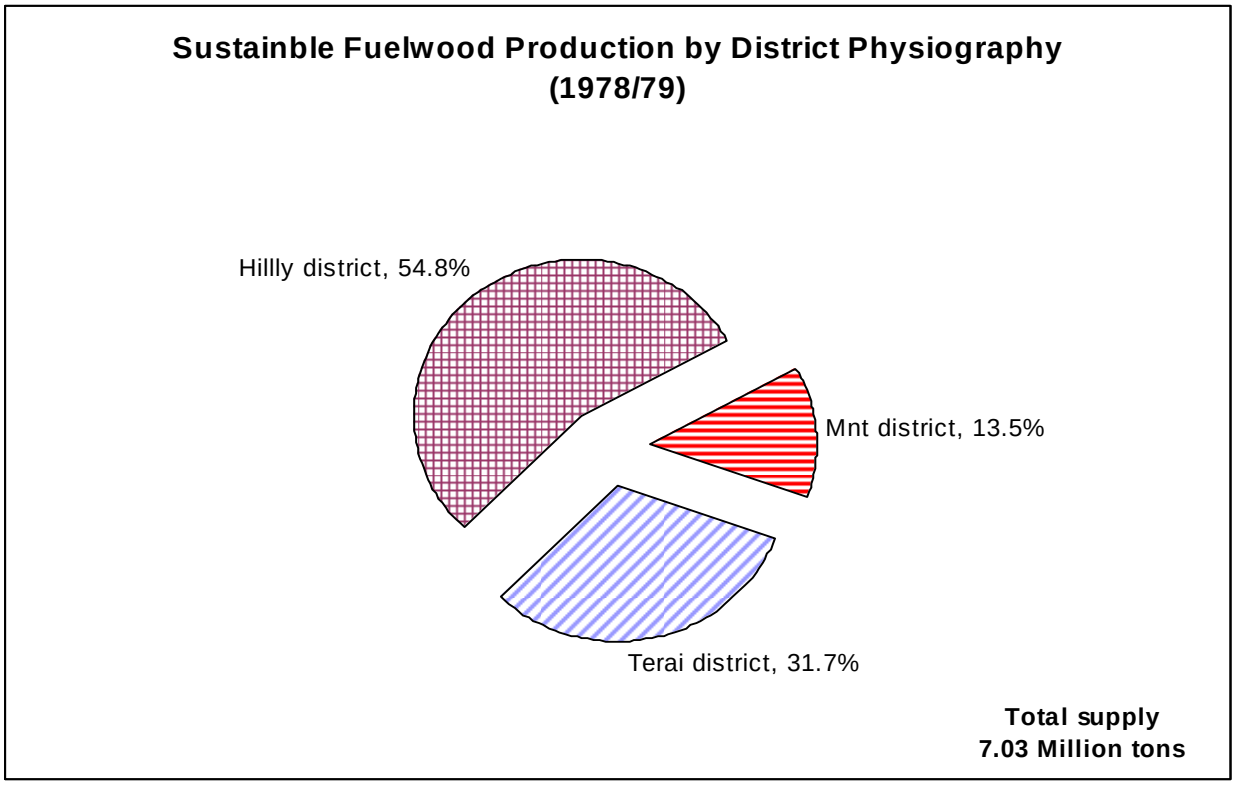


Figure 2.17: Sustainable Fuelwood Supply by District Physiographic Region



2.1.1.15 Sustainable Fuelwood Supply Assessment (1985/86)

Sustainable wood yields is defined in this study as the sum of recoverable stem and branch growth and stem and branch mortality. Because the need for fuelwood in Nepal is much greater than for tiimber, it is assumed that 85% of the stem growth wood be fuelewood as well as all of branch growth and stem and branch mortality. MPFS (1988b) has assumed recovery factors of 70% for the Himalayas and High Mountains, 80% for the Middle Mountains, and 90% for the Siwaliks and Terai while assessing the sustainable annual wood supplies. Table 2.18 shows the sustainable annual wood supply from Nepal's forests (1985/86).

Table 2.18: Sustainable Annual Fuelwood Supply from Nepal's Natural Forests (1985/86)

Prod in 000 ton

Region	Annual Yield (ton/ha)	Gross Supply	Accessible Supply from		Forest &Shrub
			Forests	Shrubland	
FWDR	3.5	3398	1726	22	1748
MWDR	3.0	4849	1489	26	1515
WDR	2.7	2413	1108	61	1169
CDR	3.3	3447	1244	110	1354
EDR	2.6	2329	930	171	1101
Total	3.0	16436	6497	390	6887

Source: MPFS (1988b)

The sustainable annual fuelwood supply from Nepal's Natural Forests (1985/86) by physiographic region is given in annex 2. Table 2.18 provides the sustainable fuelwood supply from accessible area of all land use by development region. The total sustainable supply from accessible area was about 8.7 million tons out of which 22% was coming from FWDR as the largest one. The WDR and EDR had equal status in this regard providing about 18% sustainable supply. Table 2.19 provides the sustainable fuewood supply from accessible areas of all land use types by development region.

Table 2.19: Sustainable Annual Fuelwood Supply from Accessible land by Dev Region (1985/86)

Prod in 000 tons

Sum of Gross	Development region					Grand Total
Landuse type⇧	FWDR	MWDR	WDR	CDR	EDR	
Cultivated land⇧	131.3	197.4	251.6	269.8	315.7	1165.9
NCI⇧	78.0	122.8	158.0	164.9	164.9	688.6
Grassland⇧	11.0	18.5	9.4	5.4	7.2	51.5
Forest۞	1726.0	1489.0	1108.0	1244.0	930.0	6497.0
Shrubland۞	22.0	26.0	61.0	110.0	171.0	390.0
Grand Total	1968.3	1853.7	1588.0	1794.1	1588.9	8792.9

Source: ۞MPFS (1988b); ⇧ WECS estimates

Similarly, sustainable fuelwood supply from accessible areas of all land use by physiographic region is presented in table 2.20.

Table 2.20: Sustainable Fuelwood Supply from Accessible Land use (1985/86)

Prod in 000 tons

Landuse type	Development region					Grand Total
	High Himal	High Mnt	Mid Mnt	Siwaliks	Terai	
Cultivated land	3.1	93.2	467.2	102.8	499.7	1165.9
NCI	0.7	102.1	460.2	40.7	84.9	688.6
Grassland	26.1	15.0	8.2	0.5	1.7	51.5
Forest	182.5	1929.8	2132.3	1693.1	559.3	6497.0
Shrubland	37.0	97.2	223.2	16.0	16.6	390.0
Grand Total	249.4	2237.3	3291.1	1853.1	1162.1	8792.9

Source: MPFS (1988b) and WECS estimate

Earlier estimation of sustainable fuelwood production was based on the availability of the tree resources in different land use categories. Forest is the major land use category providing largest amount of fuelwood both in local and national level. The other sources of land categories for fuelwood productions are cultivated land, shrubland, grassland, non cultivated public land, roadside, canal side etc. MPFS (1988) has estimated 6.8 million tons of fuelwood production from the Natural Forests only for the year 1985/86. Fuelwood is a product of wood biomass. Wood biomass per hectare by physiographic and development region is presented in table 2.21 below.

Table 2.21: Wood biomass stock (t/ha/) in 1985/86.

Zone	Development Regions					Nepal
	FWDR	MWDR	WDR	CDR	EDR	
High himal	176	145	101	115	159	139
High mountain	156	173	109	108	97	129
Mid mountain	94	97	56	54	49	70
Siwaliks	103	94	104	113	97	102
Terai	151	140	109	146	160	141
Total	136	130	96	107	112	116

Source: MPFS (1988a)

2.1.1.16 Wood Yields

Table 2.22 shows sustainable wood yields from unmanaged forests. The figure includes both stem and branch biomass coming from growth and mortality. The yield of timber wood may actually be greater but the demand is much more for fuelwood than the timber.

Table 2.22: Sustainable annual wood yields (tons/ha/year) from natural forests

Zone	Development Regions					Nepal
	FWDR	MWDR	WDR	CDR	EDR	
High himal	3.4	3.0	2.0	1.6	2.2	2.4
High Mnts	3.6	3.2	2.9	2.2	2.7	2.9
Mid Mnts	2.7	2.5	2.3	2.0	2.0	2.3
Siwaliks	3.4	3.5	4.3	4.9	4.3	4.1
Terai	6.7	6.3	6.1	6.5	7.0	6.5
Total	4.0	3.7	3.5	3.4	3.6	3.3

Source: MPFS (1988a)

DFRS/FRISP (1999) has assessed the total biomass available in the forests. Total stem volume (over bark) of reachable forests of Nepal was 388 million cubic meters and the total biomass of stems, branches and leaves is 429 million tonnes (air dry). For the whole country, the projection of total volume and biomass is estimated at 759 million cubic metre and 873 million tones respectively. The mean stem volume (over bark) of Nepal is 178 cubic metre/ha, the mean stem volume up to 10 cm top is 131 cubic metre/ha and the average number of stems per hectare is 408 (DFRS, 1999). Table 2.23 shows the total sustainable fuelwood production in the year 1994/95 based on the volume and biomass production. There are two reasons to explain the increase in the fuelwood production in the year 1994/95. The earlier estimation of sustainable fuelwood supply for the year 1994/95 was made based on the fuelwood yield as suggested by WECS (1988) study. Whereas, this report has used the sustainable fuelwood yield from natural forests as suggested by MPFS (1988b). However, sustainable fuelwood yield from shrubland is taken from the WECS (1988) findings.

Table 2.23: Annual Sustainable Fuelwood Supply in Development Region (1994/95)

Unit in 000 MT

Region	Gross Supply (Forests & Shrub)	Reachable Supply from		Reachable supply from forests & Shrub
		Forests	Shrubland	
FWDR	2588.0	1255.8	95.0	1350.8
MWDR	3882.2	1363.2	116.2	1479.4

WDR	2159.9	707.67	63.3	770.9
CDR	3192.7	1741.41	92.7	1834.1
EDR	2164.1	1498.38	195.9	1694.3
Total	13986.8	6566.46	563.1	7129.6

Source: WECS Estimate

Table 2.24 reveals the sustainable fuelwood supply from accessible areas of different altitude range. The sustainable supply from the gross area of forest land is nearly 14 million tons out of which only 50% is supplied from the reachable forests. Annual sustainable supply from both forests and shrubland is more than 7 million tons. The total sustainable supply is taken from the development region estimates and sustainable supply in different altitude range is calculated based on the proportional distribution of reachable forests and shrubland. Reachability of the shrubland are assumed to be equal the reachability of forests.

Table 2.24: Annual Sustainable Fuelwood Supply from Reachable Area in by Altitude Range (1994/95)

Unit in 000 MT

Region	Reachable Supply		Forest &Shrub
	Forests	Shrubland	
0-500	2578.3	221.1	2799.4
501-1000	1102.3	94.5	1196.8
1001-1500	900.4	77.2	977.6
1501-2000	743.0	63.7	806.7
2001-2500	535.1	45.9	581.0
2501-3000	534.5	45.8	580.4
>3000	172.8	14.8	187.7
Total	6566.5	563.1	7129.6

WECS estimate

Table 2.24 shows that more than one third of the total annual sustainable supply from reachable forests and shrubland comes from lower altitude that is southern belt of the country namely the Terai and some Siwalik region. Contrary to this, only about 187 thousand tons of fuelwood can be derived from the altitude of more than 3000 meters in sustainable basis.

Annual sustainable fuelwood production by development region and land use types for the year 1994/95 is given in table 2.25. The total sustainable production is about 9.0 million tons out of which forest land alone contributes more than two third of the total. Production from cultivated has remained the same as it was in the year 1985/86 because this report has assumed that tree growing practices in the cultivated land is almost same. In the earlier time, naturally grown forest and trees were found in such land categories where planted trees with manageable size and species are mostly found in the recent time.

Table 2.25: Annual Sustainable Fuelwood Production from Accessible Land use in Dev Region (1994/96)

Unit in 000 MT

Landuse type	Development Region					Grand Total
	FWDR	MWDR	WDR	CDR	EDR	
Cultivated land	131.3	197.4	251.6	269.8	315.7	1165.9
NCI	78.0	122.8	158.0	164.9	164.9	688.6
Grassland	11.0	18.5	9.4	5.4	7.2	51.5

Forest	1255.8	1363.2	707.67	1741.41	1498.38	6566.46
Shrubland	95.0	116.2	63.3	92.7	195.9	563.1
Grand Total	1571.1	1818.1	1190.0	2274.2	2182.1	9035.5

Source: WECS estimate

WECS has used average annual sustainable fuelwood yield equal to 2.1 tons/ha and MPFS (1988b) has used the yield factor equal to 3 tons/ha. MPFS (1988b) has considered 3.3 tons/ha yield of total wood products including timber and fuelwood. WECS (2006) has estimated about 6.4 million tons of sustainable fuelwood production from all categories of resource types in Nepal for the year 2004/05. The figure was about 6.8 million tons for the year 2000/01.

2.1.1.17 Sustainable Fuelwood Supply in 2008/09

The sustainable supply of fuel wood from reachable area of all land resources type for the year 2008/09 is presented in Table 2.26. The sustainable supply was about 12.5 million tons for the same year. This estimate is significantly different than the previous year's estimation because it includes the community forest as the managed forest regime which has almost double or more annual wood yields as compared to the productivity of unmanaged natural forests. This report has also used the higher annual fuelwood yields (tons/ha/year) than the WECS (1988) study. However, a little change is made in the proportion of timber yield and fuelwood yield. This report is further based on the proportion of timber yield and fuelwood yield equal to 25% and 75% respectively of the total annual wood yield. Reachability of all land use is assumed to be the equal of years 1994/95.

Table 2.26: Annual Sustainable Fuelwood Production by Land use and Region (2008/09)

Unit in 000 MT

Landuse type	Development Region					Grand Total
	FWDR	MWDR	WDR	CDR	EDR	
Cultivated land	131.3	197.4	251.6	269.8	315.7	1165.9
NCI	78.0	122.8	158.0	164.9	164.9	688.6
Grassland	11.0	18.5	9.4	5.4	7.2	51.5
Forest	1619.6	2177.2	1306.7	2372.9	2561.2	10037.6
Shrubland	95.0	116.2	63.3	92.7	195.9	563.1
Grand Total	1934.9	2632.1	1789.0	2905.7	3245.0	12506.6

Source: WECS estimate

Forest land contributes more than three forth of the total sustainable fuelwood production in the country. Furthermore, cultivated land supplies 9.3%, NCI 5.5%, shrubland 4.5% and grassland 0.4% respectively.

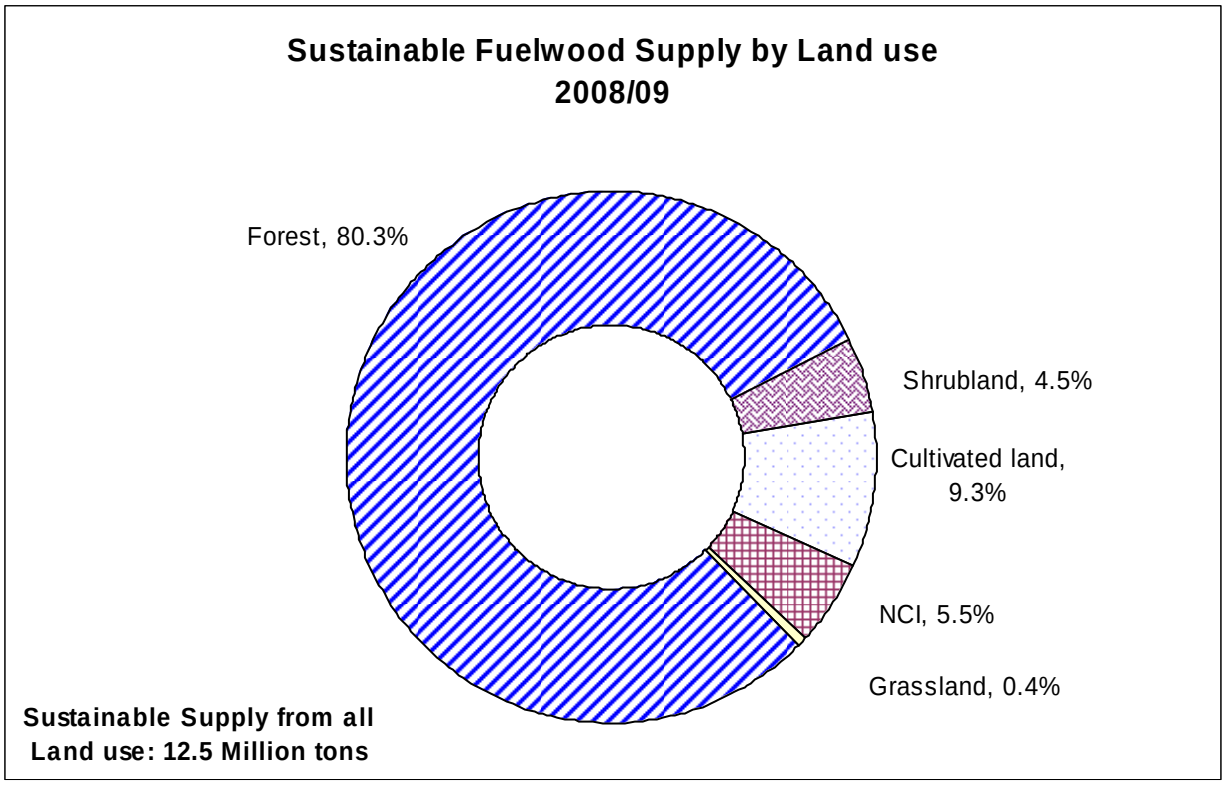
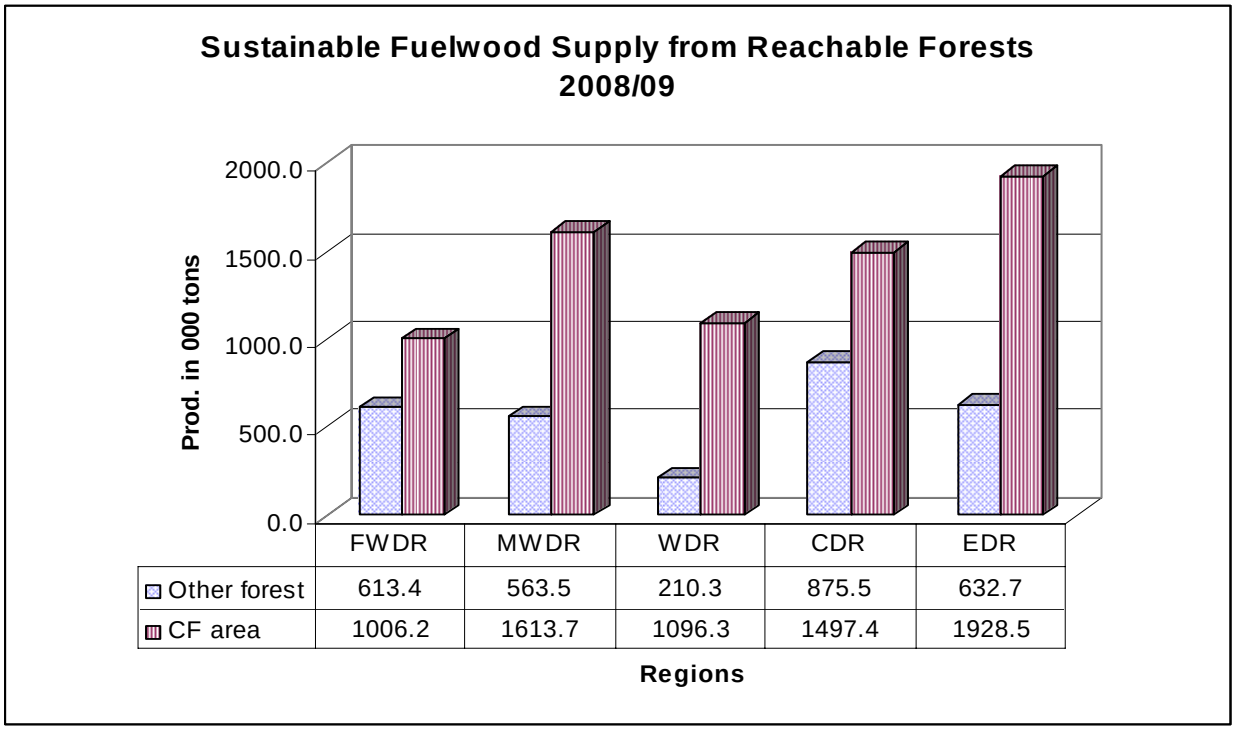


Figure 2.18: Sustainable Fuelwood Supply by Land use

This report has assessed the sustainable fuelwood supply based on the management regime. Most of the reachable forests specially in hills and mountain regions are already handed over to the community as the community forests. However, CF in Terai region still occupies small areas of the total forests. Community forest is one of the major sources of fuelwood production in Nepal. It has now covered more than a quarter of total national forests. Community Forest User Groups (CFUGs) are managing the forest as per prescribed operational plan. Interestingly, about 40% of the total country's population is involved in this system and they are getting benefits in different ways. Figure 2.19 gives the figure of sustainable fuelwood supply from the community forests and other forests category. This estimate only includes the reachable area of the forests assuming 100 % reachablility in community forests.

Community forests are considered as the managed forests while assessing the sustainable fuelwood supply for this report. Majority of community forests are being managed as per prescribed operation plan and therefore can be considered as the scientific management regime. This report has therefore considered high level of productivity factor for this forest regime. Terai region of Nepal has higher annual increment of growing stock compared to hills and mountain region. Productivity of such community forests is difficult to define because such figures are quite different even within the same physiographic regions.

Figure 2.19: Sustainable Fuelwood Supply from CF and Other Forest land (2008/09)



Community Forestry Guideline has suggested to consider 2% annual increment while assessing the annual allowable cut. However, for this report, wood biomass supply (tons/ha) from managed forests is derived from the MPFS (1988b). Such figures are 5.8 tons/ha for Mountain, 7.9 tons/ha for Siwaliks and 9.6 tons for Terai in the forest age of 25 years. Productivity of Siwalik region is used to estimate the sustainable fuelwood supply of Hilly region. Furthermore, this report also considers that all the community forests are within the limit of reachability. Table 2.27 provides the estimate of Annual sustainable fuelwood yield in community forests by development region and physiographic region.

Table 2.27: Sustainable Fuelwood Production from Community Forest (2008/09)

Unit in 000 MT

Dev Region	Phy Region			Grand Total
	Hills	Mountain	Terai	
FWDR	617.8	278.5	110.0	1006.2
MWDR	827.7	194.6	591.4	1613.7
WDR	979.3	29.3	87.7	1096.3
CDR	1077.8	244.1	175.6	1497.4
EDR	1425.3	247.3	256.0	1928.5
Grand Total	4927.8	993.6	1220.7	7142.2

Source: WECS estimate

The highest fuelwood production comes from EDR supplying about 27% of the total production of community forests. Near about one forth of the supply comes from MWDR followed by CDR, WDR and FWDR respetively. Table 2.28 provides the contribution of community forests and other forests land in supplying the sustainable fuelwood in different development region. MWDR,

Table 2.28: Distribution of CF and Other forests in supplying the sustainable fuelwood (Percent)

Region	Other forest	CF area	Total supply
FWDR	21%	14%	16%
MWDR	19%	23%	22%
WDR	7%	15%	13%
CDR	30%	21%	24%
EDR	22%	27%	26%
Total	100%	100%	100%

Extraction and consumption of the fuelwood derived from community forest can be different than that of its sustainable production.

2.1.2 Animal Residues

Where both woody and herbaceous biomass supply sources are scarce, not sufficient to meet the traditional energy needs of the people, there, historically animal excreta, mostly *gobar (*cow dung) either in a dried cake form or mixed with other left over herbaceous biomass like cattle shade refuses and twigs and turned into stick form, has been the important traditional energy supplement in areas located away from the remaining forests, mostly in the Tarai belt of western, central and eastern Nepal.

WECS has been estimated the annual dung supply potential for energy, only in the form of dung and not including its biogas generation potential, has been provided in table 2.29**.** The table exhibits the total dung production by development region and physiographic region for the year 2008/09. Total production is about 14.9 million tons that is enough to meet about 40% of the total energy requirement of the country. However availability of the dung is just around 80% of the total production in the country. The estimate was derived based on annual dung production per unit of animal in dry form; the total animal population included only the existing cattle and buffalo's heads in 2008/09 in different development regions of the country.

Animal waste, particularly dung, is the second most sources of indigenous energy and occupied also second largest position in terms of primary energy consumption. Animal dung in dried cake form has been the common energy for the poor, even if the energy content in dung is very low due to high moisture content. Recently, this biomass has been used for generating methane gas through anaerobic digestion, this modern form of energy produced from animal dung has become very popular and the current progress, in terms of number of new biogas digester establishment has reached more than 2,00,000 plants to date.

Table 2.29: Total Dung Production by Development Region and Physiographic Region(2008/09)

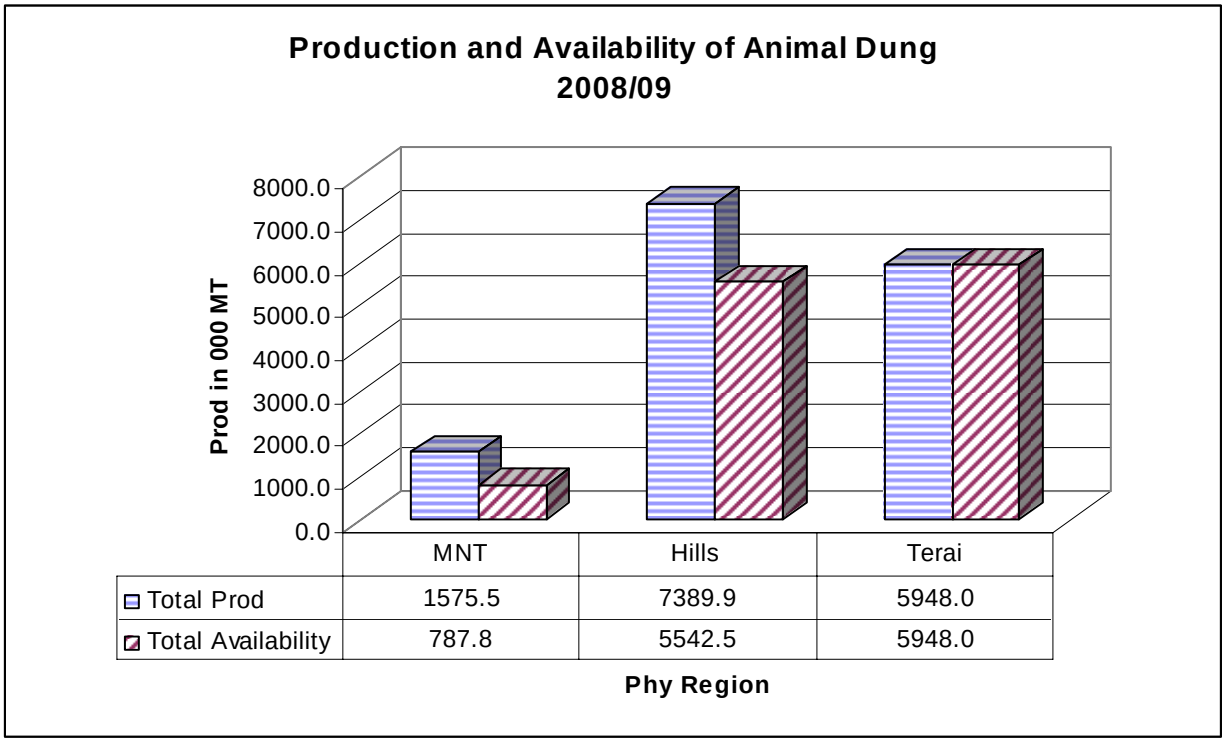
000 MT

Dev. Region	Phy. Region			Grand Total
	MNT	Hills	Terai	

EDR	465.9	1384.2	1918.5	3768.6
CDR	371.1	1730.8	1413.8	3515.7
WDR	12.0	2178.0	969.8	3159.8
MWDR	285.0	1317.1	950.1	2552.2
FWDR	441.5	779.9	695.7	1917.1
Grand Total	1575.5	7389.9	5948.0	14913.4

Animal waste particularly dung is not only the second largest source of indigenous energy but it also occupies the second largest position in consumption terms. Dung cakes are the poorest form of energy and are regarded as the energy of the poor. However, if animal waste in the form of dung is used in a biogas plant, it turns into a clean form of energy without any adverse effects to the environment and agricultural production. Here, only the supply potential of animal waste as the dung cake is estimated, though it is possible to estimate the potential supply of dung for biogas generation which has been already going popularity in Nepal. Figure 2.21 exhibits the annual production of animal dung considering its availability in different physiographic region. This report has considered the availability factor of animal dung in Mountain, Hills and Terai region are 50%, 75% and 100% respectively. Out of 14.9 million tons of total production, about 12. 2 million tons is available for utilization. It is, therefore, around 82% of the total dung production can be considered for availability for the utilization purpose.

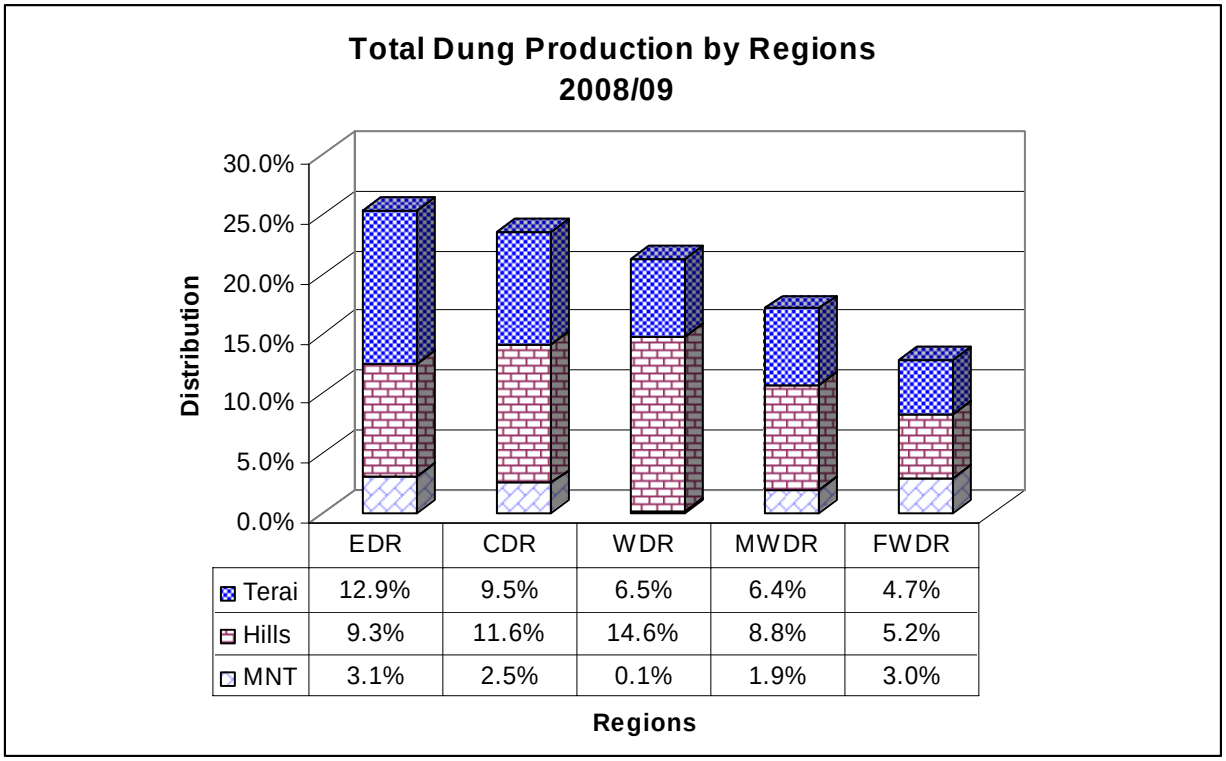
Figure 2.21: Production and Availability of Animal Dung (2008/09)



People mix animal dung with small pieces of agricultural waste and woody biomass to make dry and rigid form of dung cakes. This form of dung cake is common in the rural parts of the Terai region where natural forest does not exist in nearby areas. Like agricultural residues, it also has multiple implications in rural livelihood.

Figure 2.22 shows the total supply potential of animal dung for the year 2008/09, that can be used either in the form of dung cake to produce energy or in the form of compost manure to use in agriculture land. Figure 2.23 presents the proportional distribution of dung production by development and physiographic region.

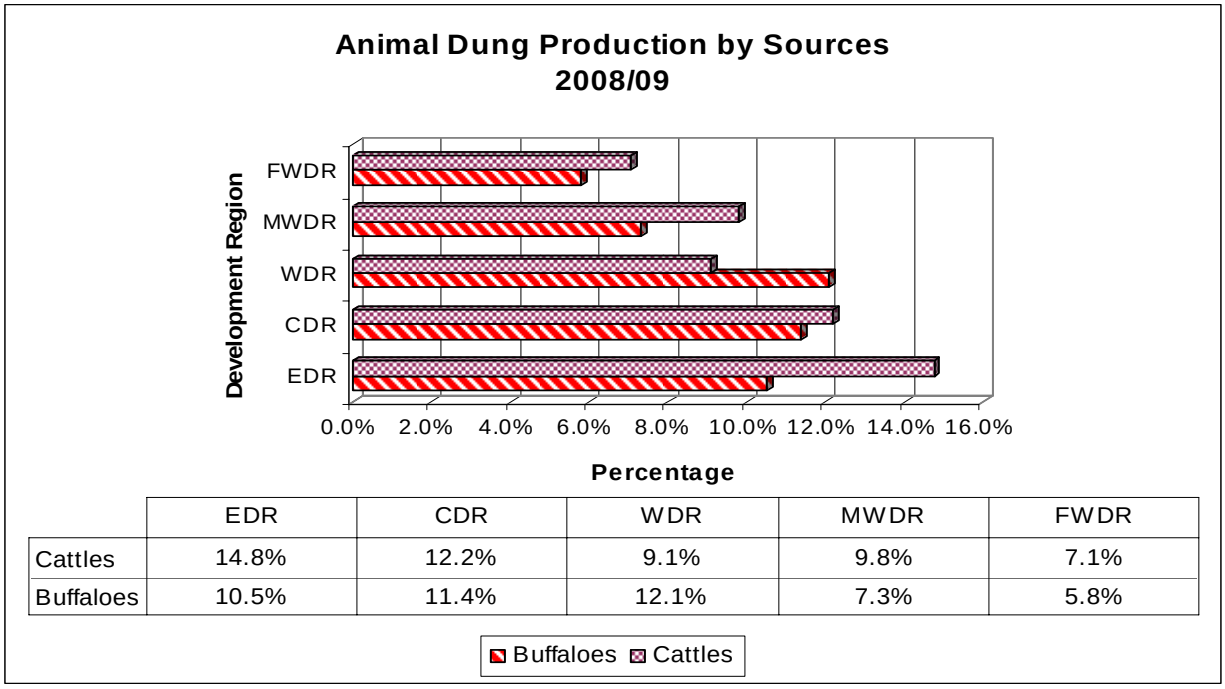
Figure 2.22: Total Dung Production by Regions (2009/09)



	EDR	CDR	WDR	MWDR	FWDR
Terai	12.9%	9.5%	6.5%	6.4%	4.7%
Hills	9.3%	11.6%	14.6%	8.8%	5.2%
MNT	3.1%	2.5%	0.1%	1.9%	3.0%

About 40% of the total energy requirement of the country can be met by animal dung alone if used only for energy purpose. It is important to note here that about 15% of the total potential of dung production has already been used for energy purpose, which can be a matter of serious concern for subsistence agricultural system of rural Nepal because subsistence oriented farming system of Nepal heavily depends on animal dung for agricultural productivity.

Figure 2.23: Distribution of Animal Dung Production by Sources



	EDR	CDR	WDR	MWDR	FWDR
Cattles	14.8%	12.2%	9.1%	9.8%	7.1%
Buffaloes	10.5%	11.4%	12.1%	7.3%	5.8%

2.1.2.1 Biogas Production

Biogas is a methane rich gas produced by the digestion of animal, human and bio-solid waste. In Nepal it is the animal waste mainly used for the biogas production. In some places the plants are integrated with toilets for the production of biogas. The digesters, where the animal wastes are digested anaerobically, is either fixed dome type or floating drum type. The fixed dome model has become popular as it is easier to construct, operate and maintain using indigenous raw materials.

The potential of producing biogas is about 1.9 million plants out of which 57 percent in Terai, 43 percent in hills and mountains. The Biogas Support Programme (BSP) under the Alternative Energy Promotion Centre and with the cooperation from various donors like SNV and KfW is promoting the installation of biogas plant in various part of the country. There are more than 2,00,000 biogas plants installed in various districts of Nepal. Also there are about 60 private biogas companies and 15 biogas appliances manufacturing workshops in the country for the effective dissemination of this technology in Nepal. Also biogas program is developed as the first CDM project in Nepal.

Currently, biogas- a modern form of energy derived from anaerobic digestion of animal waste mainly cattle dung, and recently also human excreta mixed with cattle dung in some areas, has been the alternative source of energy for cooking and sometimes for lighting in rural households, mostly in the Terai and some low lying villages in the mid-hill districts of Nepal.

BSP-Nepal (2005) present the biogas production potential based upon the number of cattle/buffalo in the country in 1997/98. Their estimate takes into account the quantity of dung

that could be available for biogas and the micro-climatic pockets where biogas production could be technically feasible in different parts of the country. Refer to Table 2.30.

Table 2.30: Biogas Potential in Nepal (1997/98)

Animal	Number (Million)	Dung available/day (kg)	Total dung available/day ('000 tonnes)	Biogas Yield per kg of Dung (m^3/day)	Gas Volume ('000 m^3/day)
Cattle	7.0	10	70	0.036	2,520
Buffalo	3.4	15	51	0.036	1,836
Total	10.4		121		4,356

Source: CMS, 1999 (in BSP-Nepal, 2005).

Considering only 75 percent of the potential could be realized due to other uses of dung, the above data indicate a potential of 2.9 million biogas plants in Nepal (smallest size biogas plant capacity 4m3). The above assessment does not take into account the droppings of poultry and the excreta of pigs and goats, nor that of human beings. If all these were added then the biogas production potential could be greatly enhanced in the country. Different studies have tried to assess the biogas potential in the country. In 1992, Wim J. van Neses (in BSP-Nepal, 2005) calculated the potential of establishing 1.3 million plants. CMS and SNV/BSP (in BSP-Nepal, 2005) assume a technical potential ranging between 1.3-2.9 million plants.

Currently, biogas- a modern form of energy derived from anaerobic digestion of animal waste mainly cattle dung, and recently also human excreta mixed with cattle dung in some areas, has been the alternative source of energy for cooking and sometime for lighting in rural households, mostly in the Tarai and some low lying villages in the mid-hill districts of Nepal.

Biogas production potential based upon the number of cattle/buffalo in the country in 2008/09 is presented in Table 2.31. BSP-Nepal (2005) estimated about 2.9 million biogas plant (smallest size of 4 m3 capacity) in the country. This assessment assumed that only 75% of the potential could be realized due to other uses of the dung. The above assessment does not take into account the droppings of poultry and the excreta of pigs and goats, nor that of human beings. If all these were added then the biogas production potential could be greatly enhanced in the country.

Different studies have tried to assess the biogas potential in the country. In 1992, Wim J. van Nes es (in BSP-Nepal, 2005) calculated the potential of establishing 1.3 million plants. CMS and SNV/BSP (in BSP-Nepal, 2005) assume a technical potential ranging between 1.3-2.9 million plants, the economic potential was considered only to be 60,000 plants. Their estimate takes into account the quantity of dung that could be available for biogas and the micro-climatic pockets where biogas production could be technically feasible in different parts of the country. Refer to Table 2.31.

Table 2.31: Biogas Production Potential in Nepal (2008/09)

Unit in 000 GJ

Dev. Region	Phy. Region			Grand Total
	Hills	MNT	Terai	
CDR	4999.7	1059.3	4066.3	10125.3
EDR	3962.0	1334.6	5488.5	10785.1

FWDR	2240.4	1261.7	2001.9	5503.9
MWDR	3767.7	798.7	2745.4	7311.8
WDR	6349.6	33.1	2794.1	9176.8
Grand Total	21319.4	4487.3	17096.2	42902.9

Source: WECS estimate

Total biogas production potential in the year 2008/09 is about 43 million GJ which is about 11% of the total energy demand of the same year. Table 2.32 provides the information on potential of biogas availability in 2008/09. Potential of biogas availability in the country is about 81% of the total biogas production. The availability factor of the biogas production in the Terai, Hills and Mountain region is 100%, 75% and 50% respectively.

Table 2.32: Potential Biogas Availability (2008/09)

Unit in 000 GJ

Dev. Region	Phy. Region			Grand Total
	Hills	MNT	Terai	
CDR	3749.8	529.6	4066.3	8345.7
EDR	2971.5	667.3	5488.5	9127.3
FWDR	1680.3	630.8	2001.9	4313.0
MWDR	2825.8	399.3	2745.4	5970.5
WDR	4762.2	16.6	2794.1	7572.9
Grand Total	15989.6	2243.7	17096.2	35329.4

Source: WECS estimate

Table 2.33: Biogas production potential in Nepal (2008/09)

Animal	Number	Dung available	Total Dung Available/Day	Biogas Yield	Gas Volume
		Kg/day	KGs	m3/kg/day	(Million m3)/year
Cattle	7175198	10	71751980	0.036	942.8
Buffalo	4680486	15	70207290	0.036	922.5
Total	11855684		141959270	0.072	1865.3

Source: WECS estimate

2.1.3 Agricultural Residues

Where woodfuel supply is limited, the field and processing residues of crops such as *paddy, maize, what, millets, oil seeds, grain legumes, jute* etc, in dry, solid form, have become the important alternative fuels to the traditional users of fuelwood for domestic energy for cooking and heating, primarily in rural areas where national forests did not exist any more, and whatever fuelwood is produced from the TOF get priority to sell in the market for cash income. The agricultural residue production potential is provided, in table 2.34.

Table 2.34: Potential Production of Agricultural Residue, 2008/09

Unit in 000 tons

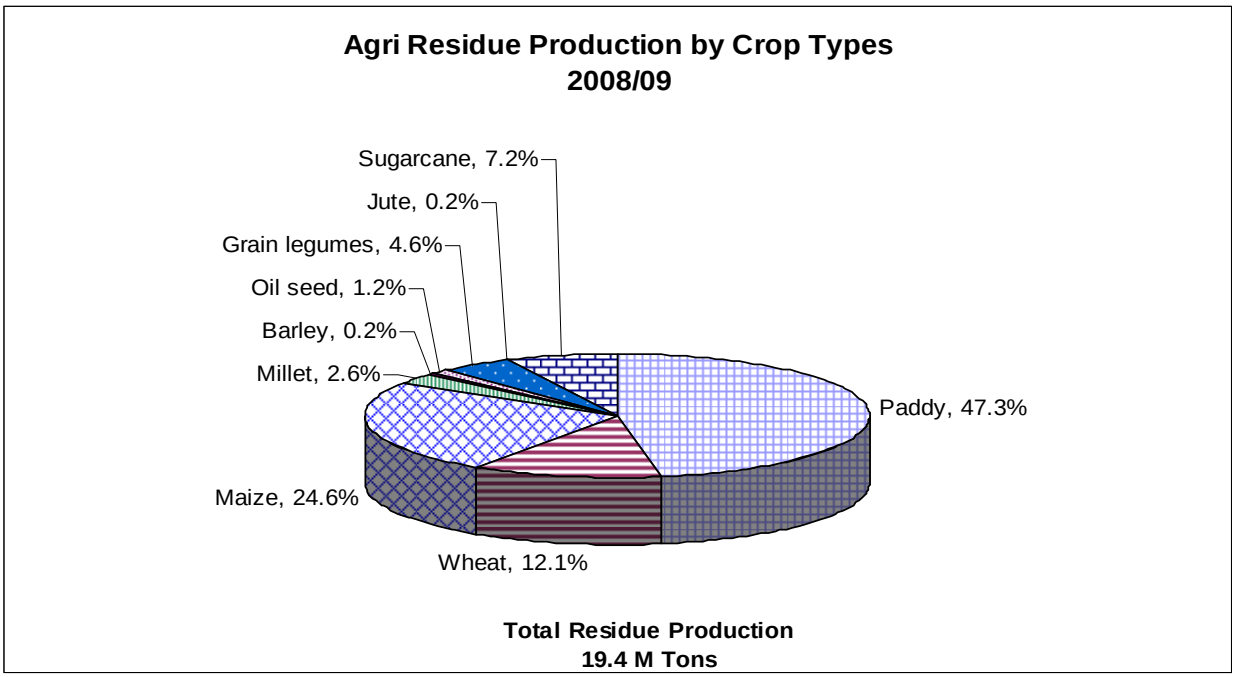
Dev. Region	Phy. Region			Grand Total
	Hills	MNT	Terai	
EDR	361.7	1436.9	3179.2	4977.8

CDR	357.5	1662.7	3939.7	5960.0
WDR	10.4	2448.1	2069.5	4528.1
MWDR	109.1	952.1	1373.7	2434.9
FWDR	141.1	296.7	1073.4	1511.2
Grand Total	979.7	6796.6	11635.5	19411.8

Source: WECS estimate

The third largest indigenous biomass source of energy in terms of consumption is agricultural residues in Nepal which directly come from the agricultural crops. Two types of residues are generally considered for energy purpose, one is field residue generated during the crop harvesting and another is process residue derived as the bi product during the agro processing. Residues collected at the field just after harvesting the main crops are named with field residues. Residues coming from agro-processing are called process residues such as rice husk, maize cob, wheat barn etc. This report has considered both the field residues and process residues while assessing the agricultural residues at national level. Only field residues were considered in earlier energy report of WECS. Report also considers only the major crop types of the country for residues production estimation. Figure 2.24 shows the contribution of individual crops in total residue production in the country. Paddy is the largest contributor in terms of crop residue production providing about 47% of the total residues. Maize gives around one quarter of the total residue production followed by wheat, sugarcane, grain legumes, millets respectively. Just three crops namely the paddy, wheat and maize provides more than three forth of the total residue production.

Figure 2.24: Contribution of Crops in Residue Production (2008/09)



Residue-to-Product-Ratio (RPR) values have been used with care while assessing the resource potential for crop residues. Actual values of RPR vary widely depending on local conditions, crop species and moisture content. Generated residues may not be available for energy purpose

because they may be already in use for other purposes such as fodder and compost manure or they may be too far away from the potential users. For this report, crop production figure is derived from MoAC (2010) report. The RPR is taken from the (Koopmans and Koppejan, 1997) paper.

Supply potential of agricultural residues is estimated at 19.4 million tons for the year 2008/09 in Nepal. This amount is equivalent to 243 million GJ in terms of energy that becomes about 61% of the total energy consumption of the same year. Table 2.35 shows the energy production potential of agricultural residues in 2008/09.

Table 2.35: Energy Production Potential of Agricultural Residue (2008/09)

Unit in 000 GJ

Dev. Region	Phy. Region			Grand Total
	Hills	MNT	Terai	
CDR	20883.8	4490.1	49483.1	74857.0
EDR	18047.7	4542.9	39930.3	62520.8
FWDR	3727.1	1771.6	13481.7	18980.4
MWDR	11958.4	1369.8	17253.6	30581.8
WDR	30748.0	131.1	25993.3	56872.5
Grand Total	85365.0	12305.5	146142.0	243812.5

Source: WECS estimate

It is therefore indicative that more than two thirds of the total energy requirement of the country can be supplied solely from agricultural residues while considering the heating value of the resources. Paddy produces near about half of the total crop residues production followed by maize (24%), wheat (12%) and rest of the residues from sugarcane, grain legumes, millet, oil seed, jute, barley etc.

Above figure don't considers the fodder ratio of the agricultural residues. This fodder ratio also varies greatly from crops to crops. Paddy residues are considered as the highest fodder ratio than others. A tentative fodder ratio of paddy is 0.66, maize is 0.28, oil seed is 0.5 and grain legumes is 0.85. In Nepal, at least 50% of the total agricultural residues can be considered for fuel purpose without affecting the other uses of the same resources.

Residue to Product Ratio (RPR) and fodder to crop ratio (FCR) of major crop types are different. Fodder to crop ratio of paddy crop is very high compared to other crop types. It is because paddy stalk is the major feed source for domestic animals in Nepal. And this fodder ratio can vary from place to place and time to time as well. Jute has been considered as the zero value of fodder for domestic animals while estimating the crop residues.

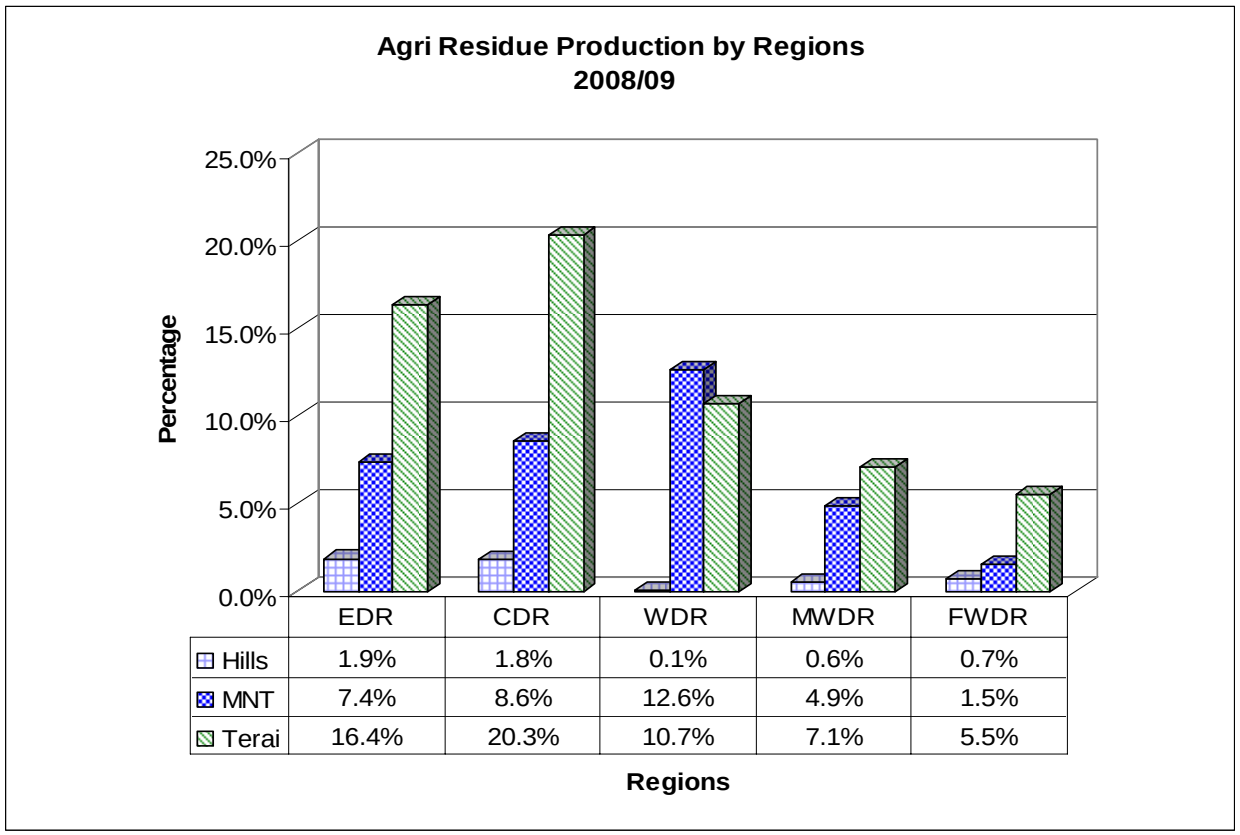
2.1.3.1 Supply Potential of Agricultural Residue by Regions

Figure 2.25 shows how the supply potential of agricultural residues varies from one region to another. This comparison is important in Nepal to show how the levels of economic activities affect in biomass energy consumption and supply as well. Largest amount of residue is produced in the CDR followed by EDR, WDR, MWDR and FWDR respectively. This is also proportional to the size of agricultural land in each region. Composition of residue production by crop types varies from one region to another. Production of maize and paddy residue occupies more than

three forth of the total potential and contribution from paddy alone is more than 47% in all regions. Paddy and maize crops are therefore not only important from food security point of view but also important from energy security perspective.

Terai is the basket of food production in Nepal. This region is rich in both productivity and accessibility terms. Figure 2.25 shows the potential of crop residue production by physiographic regions. About 60% of the total residue production comes from Terai alone and contribution of Mountain region is very low in this regard (5%). Nearly 50% of the residues in Hills and Mountain region come from maize, while paddy is the largest source of residue in Terai (58%). Supply potential alone does not tell much if the intervention is necessary to manage this resource for multiple uses.

Figure 2.25: Agri residue Production by Regions



	EDR	CDR	WDR	MWDR	FWDR
Hills	1.9%	1.8%	0.1%	0.6%	0.7%
MNT	7.4%	8.6%	12.6%	4.9%	1.5%
Terai	16.4%	20.3%	10.7%	7.1%	5.5%

2.1.4 Other biomass-waste production potential

The other biomass waste having energy potential include municipal solid waste and forest- and agro-industry wastes. ADB/ICIMOD (2006) reported that there were 58 municipalities of varying sizes in the country that generated over 1,350 tons of solid waste every day. Among them, the Kathmandu Municipality was the largest one and produced 383 tons of solid waste on a daily basis, which was slightly less than one-third of the total municipal waste generated in the country. In the Municipal solid waste the household waste comprised of about 75 percent. The per capita solid waste production per day varied from 0.11 to 0.93 k (average 0.34 kg) per person. The households on the outskirts of smaller towns were rural in nature and used most of

the waste for feeding domestic animals. This report cited SWMRMC (2004) for presenting the composition of solid wastes generated in the municipal areas of Nepal, which comprised of:

- Organic material 66 percent by weight (with a range of about 39 to 95 percent from municipality to municipality);
- Metal, glass paper, and plastic combined, 20 percent by weight (range 5 to 50 percent), plastic alone constitutes 7.6 percent (range 1.6 to 21 percent);
- Inert material 9.6 percent (range 0 to 37 percent); and
- "Other" (including medical waste) about 5 percent.

Another source (ICIMOD/MoEST/UNEP, 2007) stated that, "Solid waste generation rates vary depending upon living standards, livelihood practices, and consumption patterns." It was also of the view that the waste generation rate has changed over the years in the urban areas, and the current estimated of municipal solid waste generation in five municipalities of the Kathmandu Valley was provided as shown below in Table 2.36.

Table 2.36: Waste Generation in Five Municipalities (tons/day)

Municipality	Generation in 2004	Collection in 2004	Projected generation 2015
Kathmandu	308.4	250	547.9
Lalitpur	75.1	52	135.4
Bhaktapur	25.5	19	46.2
Madhyapur Thimi	14.3	5	27.8
Kirtipur	11.6	4	18.1
Total	434.9	330	775.4

Source: Nippon Koei 2005 (in ICIMOD/MoWST/UNEP, 2007)

From the above table it could bee seen that the five municipalities generated daily some 435 tone of solid waste, of which more than 70 percent came from the Kathmandu municipality. Currently, management of these wastes is a major burden to these municipalities. It is reported that they are forced to spend between 20-25 percent of their total expenditure on solid waste management.

In the above table, most of the contents in the municipal solid wastes belonged to the classification of biodegradable organic waste, which comprised of energy potentials but the estimated energy generation potentials of these sources is yet to be determined in the country. The non-biodegradable wastes generated in municipal areas have already been included under the municipal solid wastes in ADB/ICIMOD (2006).

However, the data concerning biodegradable wastes generation outside of these studied areas was not available for consideration of its energy potential. Besides the traditional forest- and agro-based industries such as saw mills, rice and wheat mills etc, numerous other industries also generate significant amount of biodegradable organic wastes in different shape and forms, i.e. molasses in sugar mills, black liquor in paper mills, etc. But the cumulative biomass waste production data by industry type was not available in secondary sources, which would be necessary for assessing their energy potentials.

2.1.4.1 Secondary Sources of Woodfuel

Secondary sources of woodfuels are residues from logging and wood processing industries, but also recycled wood from construction activities, packing crates, pallets, driftwood, furniture, etc.

2.1.4.2 Logging residues

Recovery rates vary considerably depending on local conditions. A 50/50 ratio is often found in the literature e.g. for every cubic meter of log removed, a cubic meter of waste remains in the forest (including the less commercial species). The logging residue consists of stump, branches, leaves, defect logs, off-cuts and sawdust. However recovery rate has been found up to 66 % in some logging areas. In some cases the residues are converted into charcoal. In order to calculate the amount of logging residues an average recovery factor of 60% has been used.

2.1.4.3 Saw-milling

Recovery rates vary with local practices as well as species. However, for calculation purposes, a residue recovery factor (yield factor) of 50% has been used (38% solid wood waste such as bark, slabs, edgings, trimmings etc. and 12% sawdust).

2.1.4.4 Plywood production

Plywood making is a large-scale operation and involves the cutting of the logs to the length required and debarking the logs. Residue recovery rates in ply wood production vary from 45 to 50% with the main variable being the diameter and quality of the log. For calculation purposes a yield factor of 50% has been used, with 45% solid wood residues and 5% in the form of dust.

2.1.4.5 Particle board production

Particleboard production basically involves size reduction of the wood, drying, screening, mixing with resins and additives, forming of the so-called mat, pressing and finishing. All types of wood are used for the production of particle board such as solid wood, solid wood residues (off cuts, trimmings), low grade waste such as hogged saw mill waste, sawdust, planer shavings, etc. For calculation purposes a residue factor of 10% has been taken, consisting of screening fines and dust while 17% of the residues are assumed to be recycled.

2.1.4.6 Perennial Plantation Crop Residue

Coconut

Coconut trees generate residues in the form of wood, fronds, husks and shells. About 12 to 14 fronds are shed per tree per year, yielding about 1.5 kg. dry woody biomass per frond or, assuming a density of 120 trees per ha., about 2,400 kg. per ha. Based on a literature survey, an residue to product (RPR) value of 0.419 for husks with a moisture content of 10.3% (based on actual measurements) while for shells an RPR value of 0.12 with a moisture content of 8.7% are used.

Others
Besides the plantation crops mentioned above, there are other sources of residues in the crop plantation industry, e.g. tea (pruning every 7-10 years of tea bushes and uprooting after productive life) and coffee (pruning of shade trees and uprooting). However, very little information is available and these have therefore not been considered.

2.2 Hydro Resources

2.2.1 Historical Background

The first Hydropower development in Nepal started with the commissioning of Pharping Power Plant in 1911 located on the right bank of Bagmati River in the South of Kathmandu valley. This power plant with a capacity of 500 KW was inaugurated on 22nd May 1911. This power plant is presently being renovated to bring it again in operation after 95 years of its establishment. The second hydropower plant was established in 1934 with an installed capacity of 900KW at Sundarijal. This power plant is still in operation and producing 640KW. Third hydropower plant with capacity of 1600 KW was constructed in 1942 at Chisang Khola (Morang district) in private sector by Morang Hydro electric Company. It later was damaged due to several landslides (Pradhan, 2006).

Prior to 1960, all the hydropower stations were constructed through grant aid from friendly countries like the ex-USSR (Panauti-2.4MW), India (Trisuli-18 MW, Devighat- 14.1 MW, Gandak- 15 MW, Surajpura-Kosi-20MW) and China (Sunkoshi-10MW). Since 1970, hydropower development took a new turn with bilateral and multilateral funding. The major donor countries in the period were Japan, Norway, Germany and South Korea including Canada, Finland, Denmark, Sweden and USA. The lending agencies were the World Bank, Asian Development Bank (ADB), Japan Bank for Industrial Corporation (JBIC) former Overseas Economic Co-operative Fund (OECF), Saudi Fund for Development, Kuwait Fund and others. From the 1990's subsequence to the adoption of the policy of economic liberalization, hydropower development took a new turn with the private sector entering the arena (MOWR, 2004). At present there is a potential opportunity for Nepal to become a major power exporter to India and at the same time earn revenue from power sales to help develop Nepal's own domestic economy.

2.2.2 Hydropower Potential

Nepal's theoretical hydropower potential has been estimated at about 83,000 MW and its technically and economically feasible potential of about 45,000 MW and 42,000 MW respectively. Table 2.37 summarizes the theoretical hydropower potential classified within the major river system in Nepal, while Table 2 and Table 3 illustrate technically and economically feasible potential as estimated by the Water and Energy Commission (WEC). The Karnali and Mahakali river systems represent approximately 43 percent of Nepal theoretical hydropower potential and 55 percent of the technical/economical potential,

Table 2.37: Theoretical Hydropower Potential

River Basin	Potential in MW		Total
	Major river courses having catchments areas above 1000 km^2	Small river courses having catchments areas 300-1000 km^2	
Sapta Koshi	18750	3600	22350
Sapta Gandaki	17950	2700	20650
Karnali and Mahakali	32680	3500	36180
Southern River	3070	1040	4110
Country Total	72450	10840	83290

Table 2.38: Technical Hydropower Potential

River Basin	Number of Project Sites	Technical Potential Capacity in MW
Sapta Koshi	53	11400
Sapta gandaki	18	6660
Karnali	30	25410
Mahakali	4	1160
Southern Rivers	9	980
Country Total	114	45610

Table 2.39: Economical Hydropower Potential

River Basin	Number of Project Sites	Economic Potential Capacity in MW
Sapta Koshi	40	10860
Sapta gandaki	12	5270
Karnali	7	24000
Mahakali	2	1125
Southern Rivers	5	878
Country Total	66	42133

The above estimates are based on Dr. Hariman Shrestha's doctoral thesis prepared in 1966 (Shrestha, H.M., 1966).

2.2.3 Hydropower Generation and Supply System

Nepal, till date, owns a number of various power plants with a total installed capacity of **689.3** MW. Out of them the ones which are grid connected, have the installed capacity of **472.9** MW and the ones (mainly small hydropower plants) which are isolated, has an installed capacity of around 4.5 MW. Besides, there are several small and medium hydropower plants with a total installed capacity of **158.3** MW which are all grid connected and owned by Independent Power Procedures (IPP). All of them put together hydropower plants alone have a total installed capacity of **635.9** MW (Privately owned micro- hydropower plants not included). The rest is being supplied by thermal (Diesel) and solar photovoltaic power plants (NEA, 2009).

Table 2.40 : Existing Power Plants and Capacity

Major Hydropower Stations – NEA	MW	INPS Connected - IPP	MW
Kaligandaki A	144.00	Khimti I (HPL)	60.00
Marsyangdi	69.00	Bhotekoshi (BKPC)	36.00
Kulekhani 1	60.00	Chilime (CHPL)	20.00
Kulekhani 2	32.00	Jhimruk (BPC)	12.00
Trishuli	24.00	Indrawati III (NHPC)	7.50

Gandak	15.00	Andhi Khola (BPC)	5.10
Modi Khola	14.80	Khudi (KhudiHP)	3.45
Devighat	14.10	Piluwa Khola (AVHP)	3.00
Sunkoshi	10.05	Sunkoshi Small (SanimaHP)	2.50
Puwakhola	6.20	Thoppalkhola (Thoppalkhola HP)	1.65
Middle Marsyangdi	70.00	Chakukhola (APN)	1.50
	459.15	Phemekhola (Khoranga HP)	1.00
		Baramchi (Unique Hydel)	0.98
Small Hydropower Stations – NEA	MW	Sisnekhola (Gautam Buddha HP)	0.75
Chatara	3.20	Rairang (RairangHPD)	0.50
Panauti	2.40	Salinadi (Kathmandu Small HP)	0.23
Tatopani/Myagdi (i) & (ii)	2.00	Sangekhola (Sange Bidyut Company)	0.18
Seti (Pokhara)	1.50		156.34
Fewa (Pokhara)	1.00		
Tinau (Butwal)	1.02		
Sundarijal	0.64		
Pharping***	0.50	Isolated – IPP	MW
Jomsom	0.24	Namche (KBC)	0.60
Baglung	0.20	Salleri (Sceco)	0.40
Khandbari	0.25		1.00
Terhathum	0.10		
	0.20		
Phidim	0.24		
Doti	0.20		
Ramechhap	0.15		
	13.84		
Diesel Power Stations – NEA	MW	Solar Power Stations – NEA	MW
Duhabi Multifuel	39.00	Simikot	0.05
Hetauda	14.41	Gamgadhi	0.05
	53.41		0.10
Total Isolated Hydropower Stations - NEA	4.53		
Total Existing	689.35	*** Not in normal operation	

Source: NEA (2009)

Nepal Electricity Authority is primarily responsible for planning, construction and operations for electric supply. Presently there are various Independent Power Producers (IPPs), who generate electricity and under the Power Purchase Agreement with NEA sell the bulk power to NEA. NEA is also in the process of unbundling and there will be separate entities for generation, transmission and distribution as envisaged in National Water Plan 2005.

Table 2.40 gives the current power plants in the country. The current installed capacity of power plants connected to the national grid is 689 MW. 23% (156 MW) of this is contributed by private sector. In addition to power being supplied by the indigenous hydropower plants, around 50MW of power is being imported from India (Vidyut, 2064). Recently, as per an agreement between Nepal and India, it is agreed to supply an additional 60MW to Nepal (Kantipur Daily, 2008).

Four more hydropower plants with a total installed capacity of 353.4 MW are under construction. Chamelia (30MW) and Kulekhani-III (14MW) are planned to be completed in 2011 and 2010/11 respectively (NEA, 2009).

Except Kulekhani –I (60MW) and Kulekhani – II (32MW) all above hydropower plants are of run-off river type. There are several other hydropower plants which have a total installed capacity of above 1000 MW and several more are under planning. Among them MOU has already been signed between GON and Indian developers for the projects Upper Karnali-300 MW and Arun-III-402 MW. Similarly Australian private company (SMEC) is developing West Seti project-750 MW. All these projects are export oriented ones. Likewise an Indian private company is developing Upper Marsyangdi project-250 MW in a joint venture with local private company. Among them the other two hydropower projects, i.e., Upper Seti and Seti Trushuli (both 128 MW each) are of storage type.

2.2.3.1 Power Demand Forecast

The Power demand projection for INPS has been carried out by NEA considering the Power consumption date of FY 2006, macro-economic indicators and rural electrification programs (Table 2.41).

Table 2.41: The Power demand projection

Year	Energy (GWh)	Peak Load (MW)	Growth in Peak Load (Annual change)
2009/10	4018.4	878.8	
2010/11	4430.7	967.1	10.0%
2011/12	4851.3	1056.9	9.3%
2012/13	5349.6	1163.2	10.1%
2013/14	5859.9	1271.7	9.3%
2014/15	6403.8	1387.2	9.1%
2015/16	6984.1	1510.0	8.9%
2016/17	7603.7	1640.8	8.7%
2017/18	8218.8	1770.2	7.9%
2018/19	8870.2	1906.9	7.7%
2019/20	9562.9	2052.0	7.6%

Source: NEA (2009)

2.2.3.2 Power Generation Expansion Plan

Table 2.42: Under Construction Power Plants and Capacity

NEA	Capacity (MW)	IPP	Capacity (MW)
Upper Tamakoshi	456.00	Mardikhola (GandakiHP)	3.10
Chamelia	30.00	Ridikhola (Ridi HPD)	2.40
Kulekhani 3	14.00	Patikhola (Unified HP)	0.99
Gamgadhi	0.40	Upper Hadikhola (CPDS)	0.99
		Seti-II (Task HP)	0.97
Total Under Construction	500.40	Total Under Construction	

Source: NEA - A Year in Review (FY 2007/08)

Table 2.43: Planned and Proposed Power Plants and Capacity

Preliminary Works in Progress		Planned and Proposed	
IPP (PPA Concluded)	MW	NEA	MW
Upper Modi	14.00	Upper Trishuli - 3'A'	60.00
Madi 1 (Annapurna Group)	10.00	Upper Trishuli - 3'B'	37.00
Mailung (MailungHP)	5.00	Budhi Gandaki	600.00
Daramkhola (Gorkha HP)	5.00	Rahughat	27.00
Lower Nyadi (Baverian HP Nepal)	4.50	Upper Seti (Storage)	128.00
Upper Malikhola (East Nepal Dev.)	3.10	Seti Trishuli (Storage)	128.00
Malikhola (Himal Dolakha HP)	2.40	Upper Modi 'A'	42.00
Phawakhola (Shivani HP)	2.07		1422.00
Lower Chakukhola (Laughing Buddha)	1.76		
Siurikhola (Nyadi Group)	0.99	IPP	
Lower Piluwa (Baneshwar HP)	0.99	Seti (West)	750
Tinaukhola Small (Namabuddha HP)	0.99	Arun 3	402
Tadikhola (Adishakti Power)	0.97	Upper Marsyangdi 'A'	121
Narayani Shankar Biomass (TMP)	0.50	Likhu 4	120
Belkhu (Multipurpose Food Ind.)	0.32	Kabeli 'A'	30
Total	352.604	Khimti II	27
		Lower Indrawati	4.5
		Balefi	20
		Upper Karnali	300
		Total	2499.5

Source: NEA - A Year in Review (FY 2008/09) *Capacity in MW

2.2.3.3 Power Demand –Supply Imbalance

Presently, the NEA system is a supply deficit one. This is being evident from load shedding being implemented for last several years. Even in, the fiscal year 2007/08 the peak power supply demand in wet season and dry season were 640 MW/542 MW and 720 MW / 308 MW respectively, resulting into load shedding of above 30 hours a week (Thapa, 2008). This kind of load shedding due to supply deficit is to continue till at least 2013/14, when, among others, Upper Tamakoshi (309 MW) is expected to be commissioned.

2.2.3.4 Transmission and Distribution

In the field of transmission, NEA is operating at system voltage levels of 132 kV and 66 kV. Rising load demands have created load saturation in some sectors of these transmission lines leading to poor regulation and reliability at the supply terminals resulting in increase in technical losses. The projects like the Middle Marshyangdi would require augmentation in the current carrying capacity of the major 132 kV network and construction of some 220 kV lines. The urgently needed 220 kV sections are Hetauda – Bardghat and Khimti – Dhalkebar. The Khimti – Dhalkebar 220 kV transmission line is under construction with loan assistance of the world Bank. It is expected to be commissioned in FY 2008/09. Efforts are underway with donors for the implementation of the 220 kV Hetauda–Bardghat section. Presently, under this section

construction of Hetauda-Bharatpur 220 kV transmission Line land associated substations are under implementation. After completion, this phase of the Project will ease transmission congestion in Hetauda-Bharatpur corridor. In addition to the above several Grid Substation Reinforcement Project, Chandranigahpur System Reinforcement Project, Kawasoti 132 kV Substation Project are also under execution (NEA, 2007/08). NEA is also constructing three power exchange links, namely, Butwal-Sunauli, Parwanipur–Birganj and Dhalkebar–Bhittamod at the 132 kV level to enhance the transfer capability of the Nepal-India cross border interconnections (MOWR, 2004). Besides, it has recently completed transmission line route alignment survey of a) Duhabi-Purnia 400 kV, 90 km, b) Butwal-Gorkhapur 400 kV, 100 km and c) Dhalkebar-Mujaffarpur 400 kV, 140 km.

At present, the Integrated Nepal Power System (INPS) consists of 1,132 km of 132 kV single circuit, 412.1 km of 132 kV double circuit, 231.46 Km of 66 kV single circuit, 161.3 Km of 66 kV double circuit, 22 Km of 66 kV and 132 double circuit, 3.37 Km of 66 kV four circuit and 2,362 km of 33 kV single circuit transmission line. Total sub-station capacity of the system is 902.45 MVA. All the Head Quarters of 75 districts of the country are provided with electricity (NEA, 2006). The remaining areas are being progressively electrified. NEA and IL & FS of India have signed memorandum of Understanding for the development of Dhalkebar-Mujjafferpur 400 kVTransmission Line.

2.2.3.5 Rural Electrification Schemes

GoN has adopted the concept of community participation in rural electrification schemes in order to accelerate the pace of expansion into the rural areas and to manage such rural distribution systems in a sustainable manner through local Users' Group cooperatives. In this regard, GoN has declared a policy, whereby 880 percent of the capital cost of electrification will be provided be the government, provided that, the community bears the balance 20 percent of the cost. Currently 47 Community Based Rural Electrification Program (CBRE) and 19 Community Based Operation and Maintenance Program (CBOM) are in operation. Agreements have been signed for another 135 CBRE and 53 CBOM Programs. 230 applications for such programs have been approved for implementation and 444 more applications have been registered with Community Rural Electrification Department for the approval. Altogether, 176,000 households are going to be added to the distribution system after completion of programs approved till F/Y 007/8 (NEA, 2007/08).

2.3 Renewable Energy Resources

The consumption of Solid biomass (traditional) forms of energy has a negative effect on the quality of lives of the people, since it takes much time to collect wood and causes adverse effects on health. Besides, the use of these traditional energy sources is neither sustainable nor desirable from environmental considerations. Therefore, there is a need to replace or supplement those energy supply system by modern forms of renewable energy. The available sources of renewable energy development in Nepal are water, sun, wind, biomass, hot spring and so on. These renewable energy sources are un-interruptible and infinitely available due to their widespread complementary technologies, which can accommodate the country's need of diverse supply. Besides, these energy sources are environmentally friendly as they have very little or no

negative impact on green house gases (GHG), landscape, climate, physical and topographical environment.

The possible renewable energy technologies, which can generate power by exploiting the locally available energy resources, are: pico-hydro and micro-hydro power, biomass related biogas, briquettes, gasifier, liquid bio-fuel, improved cooking stove, solar photovoltaic, solar thermal and wind powered plants. Of these technologies, micro-hydro, biogas, improved cooking stove, solar photovoltaic (PV) home systems, and solar water heaters are becoming popular and are at varying stages of commercialization. However, the technologies such as; solar cooker, solar dryer, briquettes, wind and geothermal are only in research and demonstration stage, which still needs commercialization. The end use status of RETs is presented in Table 2.44 .

Table 2.44 : End Use Status of Renewable Energy Technology

Technology	End use status	Advantage	Remarks
Micro-hydro	Lighting Enterprise	Access to clean energy Enterprise development	
Solar home systems	Lighting Enterprise	Access to clean energy Enterprise development Access to information	Under the owner's control
Biogas	Cooking Lighting	More comfortable fuel for cooking compared to fuel wood	Women are more benefited
Solar dryer, cooker, water heater	Cooking Water heating Drying Enterprise	Clean energy Save commercial energy/fuel wood	
Briquettes	Cooking Enterprise	Clean energy Save commercial energy/fuel wood	Women are more benefited
Improved cooking stove	Cooking Enterprise	Minimize indoor pollution Save fuel wood	Women are more benefited
Wind energy	Lighting Water pumping	Clean energy	Not very popular
Geothermal	Religious purpose Enterprise	Free energy Village/Rural Tourism Improve health	Can be mobilize for income generation
Solar water pumping system	Household Agriculture	Access to drinking water Drip Irrigation	Needs more investment

Climatologically and topographically Nepal is a diverse country. Therefore, it would be a gross exaggeration to state that a specific RET will be useful under all climatic and topographical conditions.

2.3.1 Environmental Benefits of Renewable Energy Technology

In case of Nepal the renewable energy technologies based on the locally available resources with increased efficiency and environment-friendly alternatives seems very feasible for controlling GHG emission and protecting the environment.

Meanwhile in Nepal the potential Clean Development Mechanism (CDM) projects could be implemented through renewable energy technology (RET) like Micro-hydro, Solar PV, solar thermal, biogas, wind etc. and efficiency improvement projects like improved cook stove, gasifier, briquettes etc. At present two biogas project have been registered with CDM Executive Board on 27th December, 2005 and got approval for 93,883 tonnes of emission reduction per year. The agreement has been done with the World Bank for the sale of 1 million tonnes of GHG emission reduction at the rate of US$7/tonnes CO2e (BSP, 2006). In order to obtain maximum benefit from the CDM, Nepal should conduct intensive study on the present status of GHG emission, potential CDM projects based on the RETs and other alternative options.

2.3.2 Biogas Resources

The estimated total technical potential of biogas plants is about 1.9 million plants of which 1,000,000 plants are thought to be economically viable. As of December 2008/09, more than 2,00,,000 biogas plants of varying capacities (4, 6, 8, 10, 15 and 20 m^3) have been installed (BSP, 2010). The trend observed during the period of 1998-2004 shows an increase, mainly because of the technical and financial support from BSP/SNV. The yearly installation and trend are shown in Table 2.45 . It is also noteworthy to quote that more than 90% of these plants are operational.

Table 2.45: Yearly Installation of Biogas Plant by Capacity Size

Fiscal Year	District coverage	Capacity (CUM)						Total
		4	6	8	10	15	20	
2051/52	47	62	652	1,451	2,633	279	38	5,115
2052/53	58	123	1,190	2,460	3,097	249	38	7,157
2053/54	57	304	2,004	3,201	2,686	175	17	8,387
2054/55	56	265	2,861	4,234	2,303	180	26	9,869
2055/56	56	494	4,268	4,717	1,451	109	13	11,052
2056/57	58	1,771	7,850	3,001	643			13,265
2057/58	59	3,225	11,629	2,616	387			17,857
2058/59	57	2,779	10,597	1,864	287			15,527
2059/60	57	3,391	11,105	1,622	222			16,340
2060/61	58	1,859	8,072	1,191	137			11,259
2061/62	56	2,467	13,352	1,804	180			17,803
2062/63	55	2,058	12,184	1,686	190			16,118
2063/64	60	2,463	13,486	1,550	164			17,663
2064/65	62	2,224	11,558	1,099	3			14,884
2065/66	69	3,420	14,997	1,062				19,479
Total		26,905	125,805	33,558	14,383	992	132	201,775

Source: AEPC (2010)

The most important socio-economic benefits of biogas plants are:

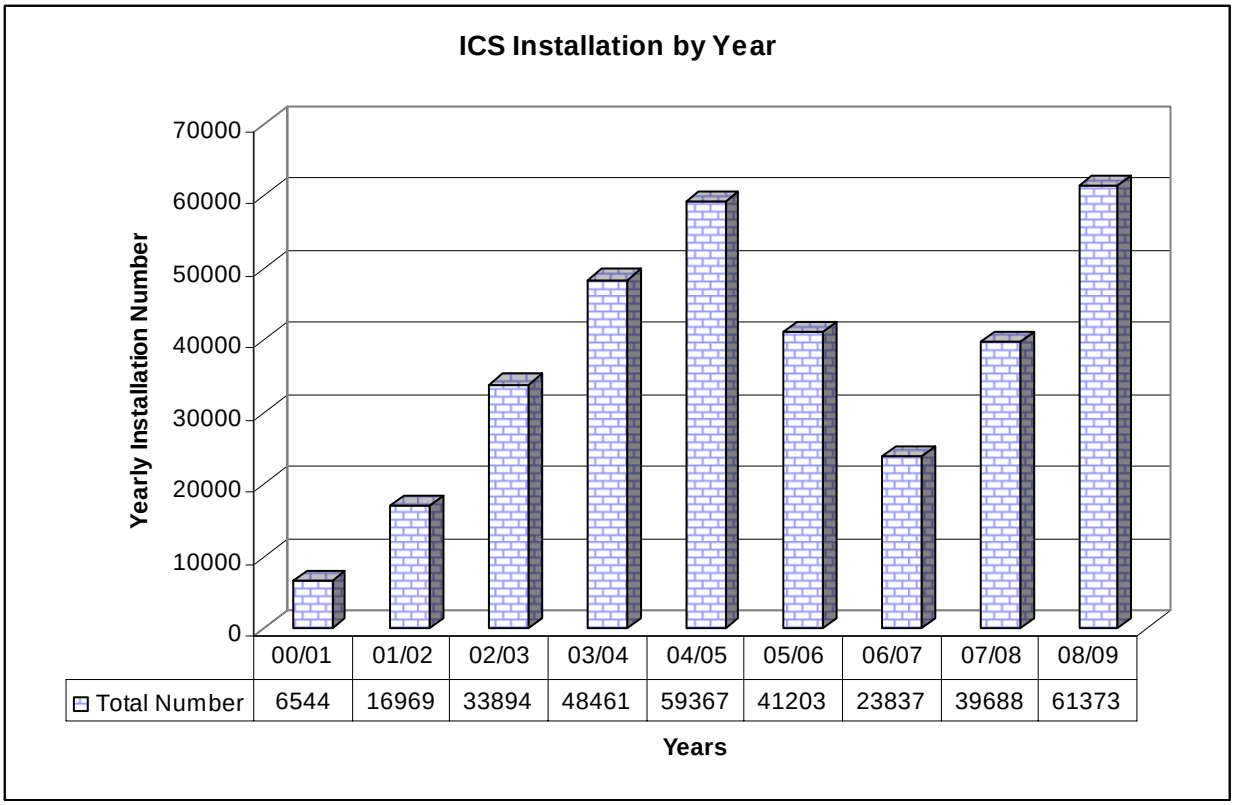
- Reduction of the workload of mainly women and girls by about 3 hours/day/household. The saved time is used for education, income generation activities and leisure.
- Annual savings of:

  - Fuel wood used for cooking to the extent of 282,024 (@2 tons/plant) (at 90%operability)
  - Agriculture waste to the extent of 49,354 tons (@0.35 ton/plant).
  - Dung cakes to the extent of 84,607 tons (@0.60 ton/plant).
  - Annual saving on kerosene of 3.5 million liters (@25 liters/plant).
- Annual reduction of GHG emissions to the extent of 987,084 tons CO2 – equivalent (@7 tons/plant).
- Annual production of 246,771 tons – dry weight (@1.75 tons/plant) bio slurry and bio compost
- Proper usages bio-slurry and bio-compost in 125,344 (at 80% households).
- Improved agriculture yields and reduced use of chemical fertilizer.
- Improvement of rural sanitations by connecting 98,708 toilets in 70% plants
- Reduction of indoor pollution due to kitchen smoke in 141,012 households.
- Reduced incidence of illness and expenses on health.
- Generation of direct and indirect employment to some 11,000 persons by Dec. 2005.
- Annual total thermal power output 443 MW (at 3.14 kW/plant/day at 90% operability).
- 550 MW electric power stations is needed to generate 443 MW thermal energy at 80% electric stove efficiency.

2.3.3 Improved Cook Stove Technology

There is a huge potential for biomass technologies like Improved Cooking Stoves (ICS), Bee-hive briquettes, Briquetting mechanism, Gasifier. More than 331,000 ICS have been so far installed through various government and non-government organizations, which is shown in Figure 2.26.

Figure 2.26 : Yearly Installation of Improved Cook Stove (Numbers)



2.3.4 Micro and Pico-Hydropower Resources

The hydro power stations for generation of mechanical and electrical energy up to a capacity of 100 kW come under micro-hydro in Nepal. The installations of such units up to 1000 kW do not require any license from the Government. Further more, EIA is not required upto 50 MW till 2011 under GoN's working program to tackle current energy crisis 2009. The Government of Nepal is providing subsidies for the installation of micro-hydro plant according to the location and remoteness of the districts of Nepal. Till 2008/09, there were about 1977 micro-hydro (including pico-hydro) electrification schemes installed in various part of the country with the total installed capacity of about 13.9 MW. Also there are about 6253 numbers of units for mechanical power generation for the milling purpose in the country.

Table 2.46: Yearly Installation of Micro hydro plants

Fiscal Year	District	Water Mills		Electrict Plant		Total	
		Capacity	Numbers	Capacity	Numbers	Capacity	Numbers
upto 2057/58	47	7064.9	799	5999	1157	13063.9	1956
2058/59	36	154	77	550.6	90	704.6	167
2059/60	39	118	59	955.7	129	1073.7	188
2060/61	33	582.6	420	526.62	103	1109.22	523
2061/62	44	1253	835	830.8	115	2083.8	950
2062/63	40	1317	878	993.9	88	2310.9	966
2063/64	41	1007	671	2081.3	168	3088.3	839
2064/65	23	2019	1346	795.1	58	2814.1	1404

2065/66	22	1752	1168	1193.56	69	2945.56	1237
total		15267.5	6253	13926.6	1977	29194.1	8230

Source: AEPC (2010)

There exists a huge hydropower potential and an ever increasing market, and as of 2008/09, there have been a total of 1977 (micro-hydro schemes with a total installed capacity of 13.9 MW (electrical) installed in various parts of Nepal since 1962. Turbine mills with a mechanical power of 15.2 MW-mechanical have also been installed.

2.3.5 Wind and Geothermal Technology

Wind is still unharnessed energy resource in Nepal. Due to its diverse topography and the consequent variation in the meteorological conditions, it is difficult to generalize wind conditions in the country. Specific areas have been identified as a favourable for viable wind energy generation. Studies made for the World Bank in 1977 indicate that in the Khumbu area, average wind speed obtainable for wind energy generation is over 5 m/s. The Department of Hydrology and Meteorology (DHM) conducted a study in 1983 and recorded wind speed data for a number of stations. The conclusion drawn by DHM indicates that wind could be used for electricity generation in the hills and for irrigation and pumping of drinking water in the Terai. The study by DANGRID, a Danish consulting firm in 1992 reported that a potential to generate 200 MW of electrical power with an annual energy production of 500 GWh from the wind resources along the 12 km valley between Kagbeni and Chusang in Mustang District of Nepal. This is about 33 percent of the present electricity production of Nepal. WECS along with DHM, Alternative Energy Promotion Centre (AEPC) and Nepal Academy of Science and Technology (NAST) carried out study on the Potential of Wind Resources in Nepal in the year 1999-2002. This study shows that there is not high potentiality of wind energy in Nepal except for some location like Thakmarpha, Khumbu and Khanjiroba, which are again on the high mountainous location and is with no infrastructural development.

As per the recently published report of AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA), the commercial potential of wind power is 3,000 MW. A pilot project for demonstrations and dissemination is being carried out by various organizations like AEPC, ITDG etc. ITDG has installed five 200-watt wind turbines at various locations like Kavre, Tansen Palpa, Makawanpur, Chisapani (Karnali), and Udayapur for the stand-alone system whereas AEPC has installed one 400-watt wind turbine at Nagarkot for demonstration purposes. In connection to geothermal energy resources, 32 hot water spring sites are situated at various parts of the country, with a water temperature up to 50° Centigrade (CES, 2000). They are used for the therapeutic purposes and a study is needed to investigate the possible end uses of the hot water spring resources.

2.3.6 Solar Energy Resources

Nepal, being located in favourable latitude, receives ample solar radiation. The average solar radiation varies from 3.6–6.2 kWh/m2/day, and the sun shines for about 300 days a year. The development of solar energy technology is thus reasonably favourable in many parts of the country. Average daily insolation in Nepal in kWh/m^2 is given in the Table in annex **2.** These

figures also emphasize high solar energy potential and possibilities of development of solar energy technology. As per the recently published report of AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA), the commercial potential of solar power for grid connection is 2,100 MW.

With National average sunshine hours of 6.8/day and solar insolation intensity of about 4.7 kWh/m^2/day, there is a huge potential for solar thermal devices such as Solar Water Heaters (SWH), Solar Dryers (SD), Solar Cookers (SC). Presently SWH have been fully commercialized and till 2009 more than 185,000 SWH have been installed in the country. SD and SC are still in the phase of dissemination and commercialization. This shows quite significant improvement in SWH installations in recent years.

2.3.6.1 Solar Electricity Generation

For a large part of the rural population consuming low electrical energy, there is no viable alternative to solar electricity for rural electrification. The operation and maintenance cost of diesel generators is too high, biogas technology does not work satisfactorily on the fairly cold high altitudes or in the mountains and would be difficult to achieve with roving herds of cattle. Small Hydro turbines need specific topographical conditions that are only found near a small percentage of users' dwellings. Solar electricity generating systems, which do not need fuel or extensive infrastructure, are easy and quick to install and thus could be very attractive option in many locations of the country. However, it cannot be claimed that solar electricity can solve rural electrification issues completely. Solar electricity too has limitations and problems but these can overcome with proper planning.

2.3.6.2 Solar Electricity Potential

The country has 300 sunny days per annum and thus is very rich in solar power potential. Using PV module of 12% efficiency, total energy generated will be 0.12* 4.5 * 147,181*10^6 = 80,000GWh/day = 17.7 TW (assuming peak sun to be 4.5 hours). This energy generated is more than energy required for fulfilling the whole energy demand of the world. The total estimated world energy demand at present is about 13 TW. If we use just 0.01% of the total area of Nepal, we can generate solar electricity of 8 GWh/day that is 2920 GWh/year (which is more thanthe energy generated by NEA in the year 2003 amounting 2261 GWh/year).

2.3.6.3 Major Users of Solar Electricity in Nepal

First officially recorded use of solar electricity in Nepal is not known. But it is said that the Nepal Telecommunications Corporation (NTC) was the first organization to use solar electricity to power a high frequency communication transceiver located in Damauli in 1974. Since then NTC has become one of the significant users of solar electricity amounting to more than 1000 kWp generating about 47000 kWh/day of electrical energy at more than 3000 locations, without national grid supplied electricity. Seventy five percent of all the Public Call Offices (PCO) in NTC are being powered by PV.

The estimated market potential is huge and about 5 MWp of photovoltaic power is currently being used in various public and private sectors (telecommunication, utility supply, stand-alone, water supply, aviation etc.) in Nepal are shown in Table 2.47

Table 2.47: Application of PV Power by Sector (until 2005)

S.N.	Service	PV Power, kWp	% Power	No. of Installation
1	Telecommunications	1001	21.6	3,000+
2	Utility supply (centralised)	100	2.1	2
3	Stand-alone system	3328	71.8	75,000+
4	Water supply	93	2.0	25
5	Aviation	37	0.8	45
6	Miscellaneous	78	1.7	100+
	Total	4,636	100	

Stand-alone Solar Home System (SHS) constitute above 5000 kWp with 185017 numbers as of until 2008/09. The installation of stand-alone SHS is shown in Figure 10. The trend of SHS installation shows a steep rise after 2000 due to the subsidy policy implemented by AEPC/ESAP. Till December 2004, 51 solar PV pumping systems have been installed, of which 28 were installed after 2000 with subsidy provided from AEPC.

Table 2.48: Yearly Installation of Solar Home System

S.N.	Fiscal Year	District	Total No	Capacity (Wp)	MW
1	Upto 056/57		11758	442652	0.44
2	057/58	35	6211	242064	0.24
3	058/59	63	13745	543486	0.54
4	059/60	65	18482	650669	0.65
5	060/61	71	15106	411095	0.41
6	061/62	67	17887	462679	0.46
7	062/63	67	6788	175052	0.18
8	063/64	61	6690	167113	0.17
9	064/65	68	34755	822964	0.82
10	065/66	73	53595	1249430	1.25
	Total		**185017**	**5167204**	**5.17**

Source: AEPC (2010)

Some INGOs are said to have installed solar pumps (3.2 kWp in Mustang) and solar PV driven mills (1.2 kWp and 1.6 kWp in Mustang) for grinding wheat and millet.

2.4 Fossil Fuel Resources

2.4.1 Coal Resources

Nepal has some sporadic deposits of low-grade lignitic coal. A very small amount of the total coal supply is extracted in Dang district for consumption in brick industries. For the major supply, coal is imported from India and abroad. Nepal Coal Limited was the sole agency for the import of coal before 1993. After 1993, NCL become inactive and private enterprises came into existence for the import of coal. These enterprises make their own agreement with Coal India

Limited or other suppliers abroad and supply coal to the market. These enterprises are entitled to fix their own prices for the coal.
There are some small occurrence of coal and lignite in Nepal, which are not commercially attractive. The occurrences of coal can be classified in to four major categories:

- Quaternary lignite of Kathmandu Valley
- Coal from Dang (Eocene coal from Mid-Western Nepal)
- Siwalik coal
- Gondwana coal

Out of these four types identified, the Quaternary lignite deposit of the Kathmandu Valley and coal from Mid-Western Nepal are of some economic significance. The Siwalik coal deposits, though widely distributed throughout the Siwalik range of the country, are small and sporadic and have not been commercially exploited. Likewise the Gondwana coal from the east of Nepal is of low quality, small in size and of no economic significance. Table 2.49 gives the primary production of coal and import statistics in Nepal.

Table 2.49: Primary production and Import of Coal Resources in Nepal

Unit in 000 tons

Year	Primary production	Import	Total
199899	10.95	104.22	115.18
199900	17.53	400.62	418.15
200001	16.59	279.84	296.43
200102	9.61	248.39	258.00
200203	11.85	215.91	227.76
200304	10.46	279.84	290.30
200405	9.29	247.88	257.17
200506	11.96	400.62	412.58
200607	19.58	239.48	259.06
200708	14.02	314.12	328.15
200809	14.82	293.76	308.58

Source: DoM&G (2010) and DoC (2010)

In the year 2008/09, Nepal imported about 293 thousand tonnes of coal from India. Kathmandu alone consumes about 40% of imported coal. It is mainly used in the industrial sector like cement, lime, and brick industries in Nepal. Primary production of coal resources within the country is about 5% of the total coal import of the year 2008/09. There are some open pit mining practices in the Dang area for the extraction of lignitic coal. The primary production of this coal is about ten thousand tonnes, which are mainly used in brick manufacturing industries. Also Nepal imports from India through private organizations under agreement with Coal India Limited.

2.4.2 Petroleum and natural gas resources

The Government of Nepal has signed two Petroleum agreements with Cairns Energy PLC, UK in 2004 for the petroleum explorations in the Blocks 1 (Dhangadi), 2 (Karnali), 4 (Lumbini), 6

(Birgunj), and 7 (Malangawa). Though the company has started its preliminary study and planning for conducting exploration works in its acreage but the actual exploration work has not been initiated. All the petroleum products consumed in Nepal are imported from India or overseas in the refined form for direct consumption. Nepal Oil Corporation (NOC) is the sole organization responsible for the import and distribution of petroleum products. The NOC has storage facility for all the essential petroleum fuels, except for LPG. LPG is bottled and distributed by private companies around all parts of the country. Table 2.50 provides the petroleum storage capacity all over the country.

Table 2.50: Petroleum Storage Capacity in Different Places of Nepal

	Petoleum fuel (unit in KL)				
Place	Petrol	Diesel	Kerosene	ATF	Total
Kathmandu	2630	6300	6300	7640	22870
Amlekhgung	1960	10380	11120	0	23460
Pokhara	350	1520	1520	64	3454
Biratnagar	560	5710	5380	280	11930
Dhangadi	100	1590	830	30	2550
Bhairahawa	140	1914	1535	56	3645
Nepaljung	140	1520	1520	280	3460
Surkhet	0	0	44	29.3	73.3
Dipaya	0	15	45	0	60
Janakpur	30	140	70	0	240
Total	5910	29089	28364	8379.3	71742.3

Source: NOC (2065BS)

Table 2.51 shows the number of Tank Trunk used in supplying the petroleum products for Nepal Oil Corporation.

Table 2.51: Number of Tank Trunk Supplying Petroleum Products for NOC

Region	Number	Percentage
EDR	176	15.3%
CDR	600	52.0%
WDR	197	17.1%
MWDR	72	6.2%
FWDR	51	4.4%
Private sector	57	4.9%
Total tank truck	**1153**	100.0%

Source: NOC (2065 BS)

Chapter 3: Energy Policy Structure

Policies in the energy sector currently are scattered in various documents and executive orders. These include policy statements of the government made in periodic development plans, sub-sector policies, government orders and notices, and laws passed by the legislature.

3.1 Periodic Development Plans

The Fifth Plan (1975-1980) policy statement of the government was the first sector specific policy statement in the energy sector. In the Plan, the government emphasized the need to reduce heavy dependence on traditional source of biomass and imported oil, and increase the supply of renewable energy sources including hydropower to meet the increasing demand for energy.

As responsibilities for development and management of this sector have been spread over several ministries, it was envisaged that an appropriate agency at the national level will be necessary to coordinate and guide the development of this sector. Shortly after the policy statement of the government, the Water and Energy Commission was established in 1975 with a mandate "to formulate and coordinate programs for the development and conservation of water and energy resources". Gradually, however, the role of the Commission with regard to planning and coordination of energy sector went into the background partly because other agencies at the national level such as the Ministry of Science and Technology and Royal Nepal Academy of Science and Technology began to emerge in the scene. More than two decades later the Commission was reorganized in January 1999 with less broader responsibilities compared to the 1975 mandate. Now the function is limited "to formulate or cause to formulate policy and strategy for conducting study, research, survey and analysis with regard to various aspects of water resources and energy development and to establish or cause to establish coordination between national and sectoral policies relating to water resources and energy" as opposed to a more broader role "to formulate and coordinate programs".

3.2 Hydropower Development Policies 1992 and 2001, Water Resources Act 1992, and Electricity Act 1992

The objectives of the 1992 Policy were to supply electricity as per the demands in urban and rural areas and meet the energy needs required for industrial development in the country. Twin laws passed by the legislature the same year made provisions to put the policies into practice encouraging the private sector through various fiscal and other incentives for development of hydropower in the country. The 2001 Policy in particular made policy announcements to utilize the hydropower potential to meet the domestic demands of electricity through transparent procedures to attract foreign and domestic investment, develop hydropower as an alternative to biomass and thermal energy, create rural electrification fund, control unauthorized uses of electricity and leakages, cover risks likely to occur in hydropower projects, demand side management and energy conservation. While some of the fiscal provisions such as scrapping of income tax holiday and bringing the hydropower projects under the usual corporate tax net which actually restricted the participation of private sector and raising of royalty payment have been implemented other procedures to encourage the private sector and regulation to provide a level playing field have not been made operational through passage of new laws.

3.3 Water Resources Strategy 2002 and National Water Plan 2005

The water resources strategy was guided by the principle of integrated water resources management. The strategy recognized that water resources development needs to be more closely integrated with sustainable social and economic development. In the hydropower sector, the strategy seeks to develop sufficient capacity to meet domestic needs at affordable prices as well as export of electricity. While putting into effect the targets set in the Strategy, the National Water Plan has fixed a target of hydropower generation of 700 MW by 2007 to meet the projected domestic demand at base case scenario without export. Similarly, a target of generation of 2,100 MW by 2017 and 4,000 MW by 2027 have been fixed to meet the projected domestic demand at base case scenario without export.

3.4 Nepal Electricity Regulatory Commission Bill 2064 (2007/2008)

Nepal Government has submitted a bill on electricity regulatory body to the parliament (Constituent Assembly) for facilitating electricity production, transmission, distribution, trading, and management in a transparent way. Its other objectives are to balance supply and demand, to set electricity tariff, to develop competition in the electricity market and to protect consumer rights. But till now, no action is being taken to enact the bill by the parliament yet. With the establishment of this regulatory body, electricity market is expected to develop in a competitive environment where stakeholders' rights are protected and electricity is made accessible, affordable and acceptable.

3.5 National Electricity Crisis Resolution Action Plan 2008

The government brought out a 38-point Electricity Crisis Resolution Action Plan in Poush 2065 (2009). The Action Plan provides for immediate, short-term and long-term programmes. The principal concessions under immediate programmes include determining a Power Purchase Agreement at flat rate for power plants up to 25 MW, 7 years income tax holiday and waiver of the provision for doing Environmental Impact Assessment (EIA) for power projects expected to go for implementation by Chaitra 2068 (2011). Such a power project will be required to do Initial Environmental Examination (IEE) only. It included plans to import more power from India, build 200 MW thermal power plant and encourage power generation through captive plants by subsidizing the additional cost involved in producing power from oil, and strengthen and add transmission capacity. It will also encourage solar and wind power generation through various concessions and facilities. Emphasis has been given to encouraging efficiency through the use of low energy consumption bulbs, initiate a system of energy audit, implement a code of conduct to save energy, and raise public awareness for demand management. The concession included 80 percent subsidy for micro hydropower below I MW capacity.

Short-term measures under the plan included building additional transmission lines to import power from India, increase power production through efficient operation of current generation facilities, control technical loss and controlling theft of electricity through cooperation of political parties, the public and local administration. The long-term programmes are building high capacity transmission lines between India and Nepal and large multi-purpose projects and adopt national integrated energy policy with short, medium and long-term energy development plan. It also includes financial restructuring of the Nepal Electricity Authority (NEA).

3.6 Ten Years Hydropower Development Plan 2009

Government of Nepal formed a task force under the convenorship of Mr. Somnath Paudel in December 2008. The task given was to formulate programs for developing 10,000 MW in 10 years to provide relief to the consumers, concerned industries and businesses against the ongoing energy crisis in the country. The task force has already submitted the draft report which is yet to be discussed among the concerned stakeholders and ratified by the government. Nevertheless, it has clearly pointed out the great importance of developing hydropower and the systematic ways and means to materialize it in this country. It has also adequately presented the scary scenario of load shedding in the years to come and the need of high level mechanism under the top leadership to resolve the crisis.

GoN has again come up with the plan of development of 25,000 MW in 20 years in the plans and programs of the Government in July 2009 under the convenorship of the Secretary, WECS. There is huge potential of hydropower resources in the country and if the Government can facilitate the development of hydropower on priority basis through private public partnership, Nepal can export the surplus power after meeting the domestic energy needs of the consumers – households and industries in the country.

3.7 Local Self-Governance Act, 2055 (1998)

The local bodies (village and district development committees and municipalities) law provides for formulation, implementation, distribution and maintenance of mini and micro hydropower projects and other energy projects in their respective jurisdictions. The law requires the local bodies to prepare resource map as well as annual and periodic plans. It provides for a detailed institutional framework and mechanisms for formulation and coordination of plans including a structure for integration of the plans. The District Development Committee is required to form an Integrated Plan Formulation Committee under the chairmanship of the President of the DDC with representation of Parliamentarians representing the district, among others.

3.8 Rural Energy Policy 2006

The current Rural Energy Policy 2006 has been conceptualized with a sector-wide approach. The Policy has been designed, in particular, with the following strategies:

- Development of a coherent rural energy policy which adequately addresses the energy needs of the rural population;
- Rural energy subsidy policy with clear objectives and criteria addressing target groups;
- Development and enforcement of efficient and effective credit systems;
- Incorporation of rural energy policies of ministries and institutions related to rural development;
- Effective cross-sectoral and donor coordination of rural energy programs;
- Adequate information campaigns and education programs; and
- A broad stakeholder involvement to ensure the whole process of technology development to project identification, design and implementation.

The policy specifically targets to install improved biomass technologies to meet cooking and other heating energy needs, micro hydro installation for rural electrification through off-grid power production and distribution that is capable to be grid-connected when grid is extended, solar home systems (10 peak watt and above) and white-led and photovoltaic based solar lights replacing kerosene lamps. The approach of the subsidy policy is to move away from per KW subsidy to per household subsidy for micro hydro for inclusion. The program of new small solar system based on small photovoltaic and white led as an immediate and intermediate solution will be more affordable to the poor. The policy recognizes solar home system as a mainstream electrification option for many rural areas where grid and micro hydro is not an option for long time to come.

3.9 Forest Sector policies and Forest Act, 1993

The forestry sector policy has evolved through distinct phases of privatization (pre-1950), nationalization (1957) and community orientation (1970). From review of forest policies of the government as expressed in periodic plans, emphasis on protection in the initial days was replaced by a phase of scientific management of the resource. Later in the post-1970s, management of the resource was replaced by an approach of popular participation of the community. The Tenth Plan (2002-2007) emphasizes promotion of conservation and sustainable use of forest resources, development of forest product-based enterprises, adoption of participatory approaches and poverty reduction to be achieved by providing opportunities for income and employment for poor, women and disadvantaged people.

The Master Plan for Forestry Sector implemented since 1988 aims to (i) meet the people's basic needs for forestry products (fuel-wood, fodder, etc.) on a sustainable basis, and (ii) protect and manage forests through people's participation. The Forest Act and Rules framed under the act are considered to be quite progressive instruments. These instruments have also laid down provisions related to private forestry. Programs like Leasehold Forestry, Hills Leasehold Forestry and Forage Development Project that help raise incomes of families in the hills below poverty line also aim to protect and conserve forests. These programs help little towards managing forests for fuel-wood. Studies have shown that "improved utilization of forests" rather than "non-use" can be more effective in raising local commitment towards conservation. The revised Forestry Sector Policy, 2000 on the other hand is specific in addressing the problem of energy in the rural areas by focusing its emphasis on managing the sector for fuel-wood. The long-term objective of the 2000 Policy is specific in meeting the people's basic needs for fuel-wood, timber, fodder, and other forestry products on a sustainable basis. The forestry resources will be managed and utilized in a manner which gives priority to the basic needs of the people such as fuel-wood for cooking, timber for housing, fodder for domestic animals, and medicinal plants for health. The strategies for production will be to promote commercial plantations especially in the Terai.

3.10 Petroleum, Coal and Natural Gas Sub-sector Policy

Nepal Oil Corporation has the monopoly to sell and distribute petroleum products (POL) in the country. It is registered under the Company Act 2021. It purchases oil from the world market and arranges to receive POL products from the Indian Oil in exchange for the imported oil. Currently

the arrangement is to import POL products from the Indian Oil on the basis of prevailing market price quoted on the 1st and 16th of each month.

POL occupies an important place in consumption of commercial energy in the country. Slow pace of hydropower development and the difficulty of replacing commercial energy by alternative sources have raised the volume of import of POL in the country, and import is expected to increase at a faster pace in the future. The import bill has already crossed over 50 percent of merchandize export earnings of the country and is rising at a faster rate because of soaring international market price of oil. Inability of adjustment of selling price in the local market to import price due to weak administration and lack of political will to increase the price of POL have added to the problem of regular supply of POL in the country.

Government with a notification in the Nepal Gazette required the NOC to distribute petrol with 10 percent of ethanol from Magh 1, 2060 (January 15, 2004) still remains to be implemented. Following the above decision of the government, the NOC's lukewarm effort to procure ethanol from the market was not successful because of the price offered by suppliers of ethanol. The supply price of ethanol at that time was not attractive enough to substitute petrol. In addition, arrangements for supply of ethanol-mix petrol at petrol pumps/stations, creation of mixing and storage facilities needed some lead time.

The national requirement of coal is being met through import due to virtual non-existence of coal mines with economic significance. Limited amount of low grade coal is locally mined in certain areas of Nepal. Coals extracted are distributed locally for use generally in brick kilns. Under the Mines and Minerals Act, 2042, coal mines are licensed and registered for their operation. Minerals are defined as any minerals extracted from the earth except petroleum. In other words, oil does not come under minerals.

A limited amount of natural gas has been found in some pockets of Kathmandu Valley. Probable reserves identified so far needs further confirmation in order to be of any use for commercial exploitation. There is lack of a clear policy on this source of energy. If the proven reserves can be used economically even for a limited number of years, it is worth exploring in view of total dependence on imported gas.

3.11 National Transport Policy 2001

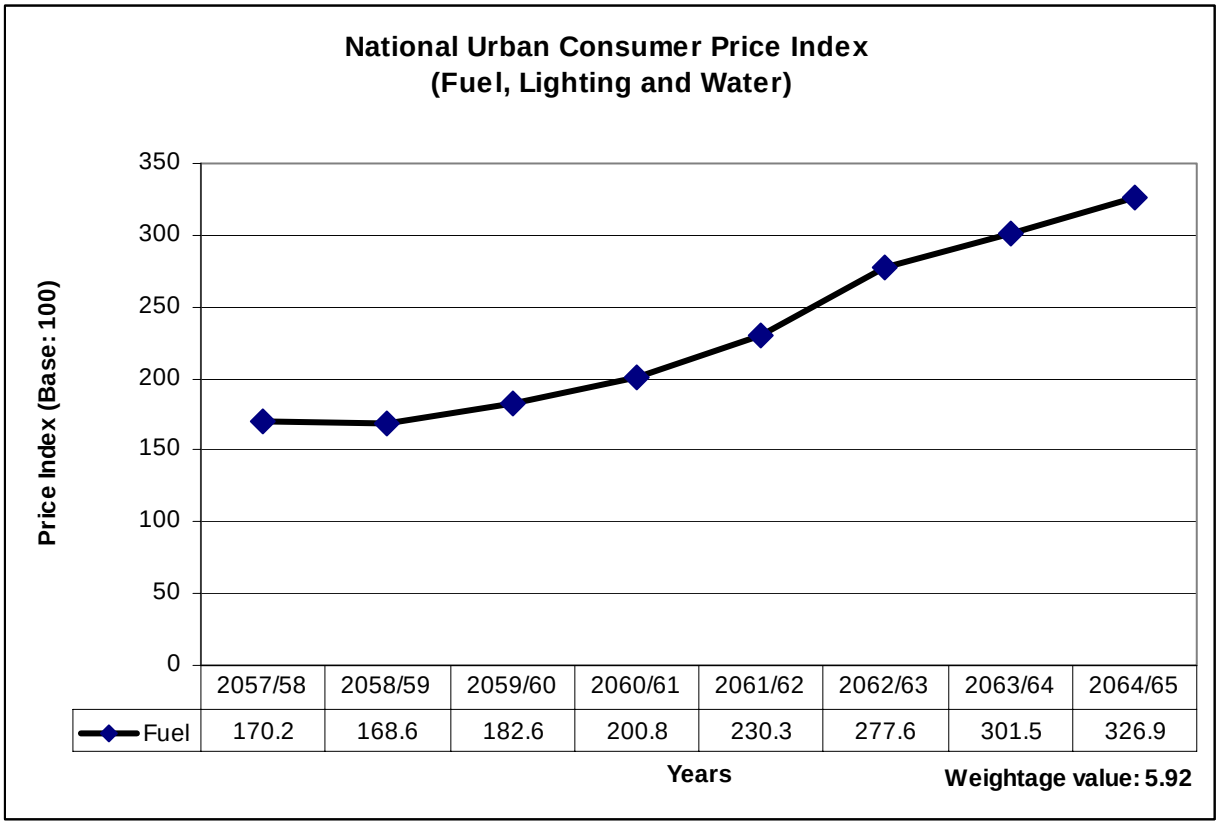
With the objective to develop a transport system that is sustainable, dependable, less expensive, safe, comfortable and self-reliant, the National Transport Policy 2001 was adopted by the government in 2001. Detailed policies to realize the above objective include, among others, developing a transport system with renewable sources such as electric and solar energy. It also emphasizes development of a transport system that is pollution free. The 2001 sectoral policy on transport system includes sections on rail transport, cable car and ropeways all with renewable energy sources. Development to date, however, remains highly focused towards road transport unlike a balanced policy of a transport system envisaged by the policy with a combination of a mix of railways, river transport and ropeways.

Chapter 4: Energy Pricing Structure

Most of the energy resources in Nepal are not traded and hence market clearing is not via the price mechanism. However, fossil fuels are imported from outside the country. Prices of electricity and petroleum are controlled by the Government whereas free market energy products namely the coal, charcoal and other petroleum products such as candles, raw petroleum, etc are set in the market. The pricing strategy of the government is somewhat related with the providing energy at low costs. Commercial energy resources particularly the electricity, petroleum and traded fuelwood are subsidized and distributed through different dealers or point.

Economic survey of Nepal 2009 has identified 19 items while assessing the consumer price index of major goods used by general Nepali people. Figure 3.21 gives the consumer price index of fuel, lighting and water assuming the base year value equal to 100 in 2052/53 BS (1993/94). The fuel item includes mainly the petroleum fuel, coal and monetized fuelwood coming through established system. Electricity price has not been increased since almost one decade. Therefore, this price index doesn't reflect the actual energy index at urban or national level.

Figure 4.1: National Urban Consumer Price Index (Fuel, lighting and water)



Source: Economic Survey (2009)

Price index value is increased from 100 to 326 during 12 years period. The weight of the given items namely the fuel, lighting and water is equal to about 5.92 percent of an average urban

consumer. Where as this value is equal to 4.95 percent for Kathmandu valley, 6.91 percent for Terai urban consumer, 5.92 percent for Hilly urban consumer.

Table 4.1 compares the market price, efficiency and effective price of the major fuel types used for cooking purpose in Nepal. The effective price of the LPG is slightly less than other fuels in terms of a single Giga Joule energy. Fuelwood only becomes cheapest once it is available free of cost or less than NRs 5 per kilogram. Efficiency of the fuel using devices is very important factors to decide the effective price of fuels. Because of the lower efficiency of fuelwood using devices, its effective price is higher than other fueltypes such as LPG, electricity and kerosene. Second highest effective price of the cooking fuel is kerosene (Rs.2652/GJ) followed by Electricity (Rs. 2604/GJ) and LPG (Rs. 2395/GJ). Average efficiency of the fuel using devices have been taken into account for this analysis.

Table 4.1: Market price, efficiency and effective price of major fuel types in Nepal

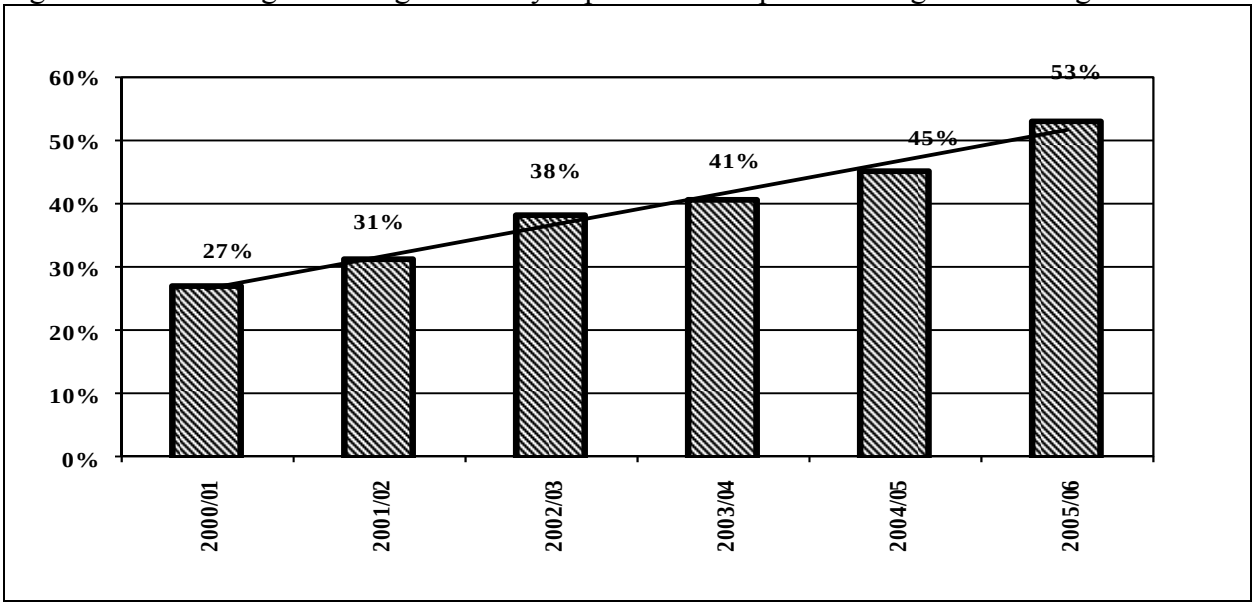
Fuel type	Natural unit	Market price (Rs/ unit)	Market price (Rs./GJ)	Average Efficiency (%)	Effective Price (Rs./GJ)
Fuel wood	Kgs	5-10	417.91	15.0%	2786.07
LPG	Cylinder	1250.00	1796.49	75.0%	2395.32
Electricity	Unit	7.50	2083.33	80.0%	2604.17
Kerosene	Litre	60.00	1591.51	60.0%	2652.52

Source: WECS estimate (2010)

About 18 million tons of fuel wood is consumed annually in Nepal, out of which less than 1% is commercialized. Rest is collected by the users free of cost from forests or their own cultivated land.

Nepal is becoming more dependent on imports of petroleum products for its meeting of energy requirements. The merchandise export of the country stands at NRs 6,200 crores in 2005/06, but the country has to spend its 53 percent for importing petroleum products. Petroleum import was just 27 percent of the merchandise exports in 2000/01 (Economic Survey, 2006/07). Due to the increase in the international prices of the petroleum products and the country's growing dependence on petroleum products, much of the export earnings are being used up for importing them. This dependence is precarious for the country's economy (Figure 4.2).

Figure 4.2: Percentage of foreign currency expenditure for petroleum against earning



Especially kerosene has become the principal source of cooking energy for the urban poor. Use of LPG has been increasing tremendously by the middle and top tier consumers in the urban areas. Both kerosene and LPG have been supplied below their economic costs for the past several years. When a product is provided below its real value, there are a lot of chances that inefficient use prevails. LPG has been continuously replacing kerosene as a source of energy for cooking in the urban and even in the rural areas. The current demand from the gas bottling industries to increase the quota obtained from NOC from 7,500 MT to 10,500 MT per month shows this trend.

If we calculate the annualized life cycle cost (ALCC) of using kerosene, LPG cooking stoves, and electrical cooking appliance for an average family of five persons in Nepal, the recent price hikes in the petroleum products have completely changed the scenario of the fuel economics.

Table 4.2: Monthly Life Cycle Costs of Cooking for an Average Nepali Family (NRs)

Year	Kerosene	LPG	Electricity
1997	180	465	605
2000	385	405	680
2003	410	510	788
2009*	912	794	788

(Based on the calculation and International Energy Initiative, 2004 and NOC, 2009)

In 1997, the monthly life cycle cost for cooking was Rs 180 for kerosene, Rs 465 for LPG, and Rs 605 for electricity. After the price revision in March 2009, the monthly ALCC turned up to be Rs 912 for kerosene, Rs 794 for LPG, and Rs 788 for electricity respectively. With the new price revision of petroleum prices, it has become evident that Nepal has to immediately substitute petroleum products by electricity for cooking in the residential, service, and other sectors. If the crude prices go upto US dollar 150 per barrel in future as during 2008, the monthly ALCC for petroleum products will be exorbitantly higher compared to that of electricity. Hence, in order to

enhance the country's supply security, it is very imperative to emphasize on development of indigenous energy resources. Besides, it is urgent to creat awareness program for consumers' switching from petroleum products to electricity especially in the urban areas where grid electricity is available. In the rural sector, it may not be possible immediately for switching to electricity because of the income disparity and the topographic terrains of the country. For rural areas, to reduce health hazards, the people should be encouraged to switch from traditional biomass energy sources to modern biomass such as biogas. They should also be encouraged to switch to the second rung of energy sources such as kerosene, LPG from traditional biomass sources in the energy ladder. Finally, the ultimate objective should be to switch over to electricity in the long run.

4.1 Electricity pricing

There are two different price structures for the electricity produced for the residential customer depending upon the type of transmission. The price structure for the electricity transmitted by national grid and distributed is regulated by the Electricity Tariff Fixation Commission, while the isolated system along with the micro hydro generated electricity fixes the prices according to the generator.
The tariff for different sector of the economy is also different. Also for the residential sector, the tariff depends upon the amount of the unit consumed. In the industrial sector, the price of electricity is less compared to other sectors of the economy. Also, NEA has introduced Time of the Day meters for effective utilization of the energy generated. The Tables 4.3 and 4.4 show different tariff structure for different sector of the economy.

Table 4.3: Existing Tariff Structure of NEA (TOD)

Consumer category and supply level	Monthly demand charge	Energy Charge (Rs./unit)		
		Peak Time	Off-peak	Normal
	Rs./kVA)	18.00-23.00	23.00-6.00	6.00-18.00
A. High voltage (66 KV and Above)				
1. Industrial	175.00	5.20	3.15	4.55
B. Medium voltage (33 kV)				
1. Industrial	190.00	6.55	4.00	5.75
2. Commercial	216.00	8.50	5.15	7.35
3. Non commercial	180.00	8.85	5.35	7.70
4. Irrigation	47.00	3.85	2.35	3.40
5. Water supply	150.00	4.55	2.75	3.95
6. Transport	180.00	4.70	2.95	4.15
7. Street light	52.00	5.70	1.90	2.85
C. Medium voltage 11 kV)				
1. Industrial	190.00	6.70	4.10	5.85
2. Commercial	216.00	8.65	5.25	7.55
3. Non commercial	180.00	9.00	5.45	7.85
4. Irrigation	47.00	3.95	2.40	3.45
5. Water supply	150.00	4.60	2.80	4.10
6. Transport	180.00	4.80	3.00	4.25
7. Street light	52.00	6.00	2.00	3.00

a) If demand meter reads kilowatts (kW) then kVA = kW/0.8

b) 10% discount in the total bill amount will be given to he HMG/N approved Industrial District
c) 25% discount in the total bill amount will be given to HMG Hospitals and Health Center (except residential complex)

Table 4.4: Existing Tariff Structure of NEA (General)

1	Domestic consumer		
	A. Minimum Monthly Charge: Meter Capacity	Minimum Charge (NRs.)	Exempt (kWh)
	Upto 5 ampere	80	20
	15 ampere	299	50
	30 ampere	664	100
	60 ampere	1394	200
	Three phase supply	3244	400
	Energy Charge		
	Upto 20 Units (Rs./unit)	4	
	21-250 Units (Rs./unit)	7.3	
	Over 250 Units (Rs./Unit)	9.9	
2	Temples		
	Energy Charge (Rs./unit)	5.1	
3	Street Light		
	A. With meter (Rs./unit)	5.1	
	B. Without meter (Rs./unit)	1860	
4	Temporary supply		
	Energy Charge (Rs./unit)	13.5	
5	Community Wholesale consumer		
	Energy Charge (Rs./unit)	3.5	
6	Industrial	Monthly demand charges (Rs./kVA)	
	A. Low Voltage (400/230 volt)		
	a. Rural and Cottage	45	5.45
	b. Small industries	90	6.6
	B. Medium Voltage (11 kV)	190	5.9
	C. Medium Voltage (33 kV)	190	5.8
	D. High Voltage (66 kV and above)	170	4.6
7	Commercial		
	A. Low Voltage (400/230 volt)	225	7.7
	B. Medium Voltage (11 kV)	216	7.6
	C. Medium Voltage (33 kV)	216	7.4
8	Non Commerical		
	A. Low Voltage (400/230 volt)	160	8.25
	B. Medium Voltage (11 kV)	180	7.9
	C. Medium Voltage (33 kV)	180	7.8
9	Irrigation		
	A. Low Voltage (400/230 volt)	-	3.6
	B. Medium Voltage (11 kV)	47	3.5
	C. Medium Voltage (33 kV)	47	3.45
10	Water supply		
	A. Low Voltage (400/230 volt)	140	4.3
	B. Medium Voltage (11 kV)	150	4.15

	C. Medium Voltage (33 kV)	150	4
11	Transport		
	A. Medium voltage (11 kV)	180	4.3
	B. Medium Voltage 33 kV)	180	4.25

The Government of Nepal, through NEA is also executing the rural electrification program. As such, it has started to sell electricity in bulk to cooperatives and communities for making the rural electrification more affordable.

4.2 Petroleum Pricing

The pricing policy for the major petroleum products such as kerosene, HSD, petrol, ATF and LPG is approved by the Government of Nepal. The NOC board can fix the price of other unregulated products. Table 4.5 presents the historical trend of retail selling price of major petroleum products.

Table 4.5: Historical Trend of Petroleum Fuels Price

Unit in NRs.

Date	Petrol/liter	Deisel/liter	Kerosene/ liter	ATF/litre	LPG/MT
2060	56.00	33.50	27.00	33.00	37,487.74
2060	54.00	31.00	24.00	33.00	
2061	56.00	31.00	24.00	48.00	43,570.28
2061	56.00	35.00	28.00	55.00	
2061	62.00	41.00	36.00	68.00	
2061	62.00	41.00	34.00	68.00	
2062	67.00	46.00	39.00	55.00	50,612.26
2062	67.00	52.50	47.65	55.00	
2062	67.25	53.15	47.65	55.00	
2063	67.25	53.50	47.25	68.00	49,389.77
2064	73.50	56.25	51.20	72.00	
2064	73.50	56.25	51.20	68.00	
2064	73.50	56.25	51.20	80.00	
2064	80.00	56.25	51.20	80.00	
2065	80.00	56.25	51.20	90.00	69,215.82
2065	80.00	56.25	51.20	100.00	
2065	100.00	70.00	65.00	100.00	
2065	95.00	70.00	65.00	100.00	
2065	90.00	65.00	65.00	95.00	
2065	85.50	60.50	60.50	90.00	
2065	80.50	59.50	59.50	85.00	
2065	77.50	57.50	57.50	80.00	
2065	77.50	55.00	55.00	70.00	
2066	77.50	58.00	58.00	70.00	63,281.52

Source: NOC (2065 BS), NOC (2065 BS), MoF (2009)

4.3 Fuel-wood Market and Prices

In Nepal, though the economic structure is a free market economy, the market of the commercial energy sector is monopolistic in nature. The market and prices of the energy fuels have a unique characteristic in Nepal. The huge energy consumed comes from the biomass sources and majority of it is non-monetized. Except for the fuel-wood supplied by the Timber Corporation of Nepal (TCN) and some back-loaded supply to the urban or market centers, all other are financially freely available. The electricity, fossil fuels and some alternative sources of energy pass through the monetized market. With about 12% of commercial energy and 0.7% of the alternative energy, in the total energy consumption share, it is about 14% of the total energy is monetized. Although these commercial fuels, especially the fossil fuels consumption constitutes a small proportion in the overall energy share, the import of it has a significant impact on the country's overall foreign exchange service.

The main sources of fuelwood were government forests in the earlier years controlled by the Ministry of Forest and Soil Conservation. Nowdays situation is shifting towards the community forests because 40% of the total population is directly use community forest products including the furelwood. The ministry officially allocates forest area to the TCN for the extraction of forest products. The unofficial extraction of fuelwood by the rural people is a common phenomenon for their self consumption. However, some part of it is traded to the market centers nearby. The fuelwood extraction and selling activities make a considerable contribution for subsistence income in many rural areas. The fuelwood prices in 2004 is given in table 4.6.

Table 4.6: Retail Price of Fuelwood at Different Location

Location	Price/Kg	
	TCN Depot	Private Depot
Kathmandu	4.00	6.00 - 8.00
Kathmandu (Crematorium)	2.80	-
Biratnagar	4.00	5.00 - 7.00
Birgunj	5.00	7.00
Hetauda	4.00	6.00
Butwal	4.00	7.00
Mahendra Nagar	3.00	5.00

Source: Gorkha Patra, October 2004

As such the official allocation of fuelwood prices is by TCN through the ministry. The TCN sets the official price of forest products at each stage of harvesting, transportation, wholesaling and retailing. TCN fuelwood price varies within Nepal depending upon transport distance from the harvesting area to the urban depot: the variation however, does not necessarily cover the differential transport cost. Supply of fuelwood from TCN depots is currently insufficient, however, to have much impact on the fuelwood prices. The market clearing prices of fuelwood is therefore determined at the private depots of the urban areas. The prices of fuelwood allowed by the Government of Nepal to be charged by TCN do not cover the full cost incurred by TCN to supply most fuelwood to the consuming centers. As a consequence of the inability to obtain sufficient extraction permits from the Ministry of Forest and Soil Conservation, almost all the depots of TCN have limited supply availability. TCN however, maintain the supply of fuelwood to crematoria, during certain critical months such as Dashain and Tihar festivals, or when they

are pressurized by the local people to provide fuelwood. The minimum price of the fuelwood per stack (500 cft) for industrial and commercial purpose while saling through tendering and quotation system is given in table 4.6 below.

Table 4.6: Minimum price of fuelwood per stack in different district of Nepal (TCN rate)

SN	District	Rate/stack (Rs.)	*App rate per kg	SN	District	Rate/stack (Rs.)	*App rate per kg (Rs.)
1	Chitwan	18,100.00	2.13	9	Kapilbastu	17,200.00	2.02
2	Nawalparasi	18,000.00	2.12	10	Jhapa, Morang, Sunsari, Banke, Dang	17,100.00	2.01
3	Makawanpur	17,900.00	2.11	11	Bardia	15,900.00	1.87
4	Bara, Parsa	17,800.00	2.09	12	Sindhuli	15,600.00	1.83
5	Rautahat	17,600.00	2.07	13	Kailali, Kanchanpur	14,000.00	1.65
6	Rupandehi	17,700.00	2.08	14	Ilam	12,600.00	1.48
7	Sarlahi, Mahottari	17,400.00	2.05	15	Surkhet	13,800.00	1.62
8	Dhanusa	17,300.00	2.03	16	Udaypur, Tanahu	17,500.00	2.06

Source: TCN (2010), * WECS estimate

The private sector has always been heavily involved in the fuelwood business in Nepal. There are more than 50 private depots in the Kathmandu Valley. Terai urban centers have fewer private depots but receive fuelwood from a greater diversity of sources, because it may come from Nepal or from India and may be delivered directly by the backloaders, by bus or truck or by rickshaw or cart.

The TCN set the official price for the fuelwood at each stage of harvesting, transportation, wholesaling and retailing. The price should be approved by the Government. TCN fuelwood price vary within Nepal depending on the transport distance from the harvesting area to the urban depot. Supplies of TCN depots are currently insufficient and have a much impact on the fuelwood price. The market clearing price of fuelwood is therefore determined in the private depots of the urban areas. Generally the market price of fuelwood is 2-3 times higher than that of the TCN price.

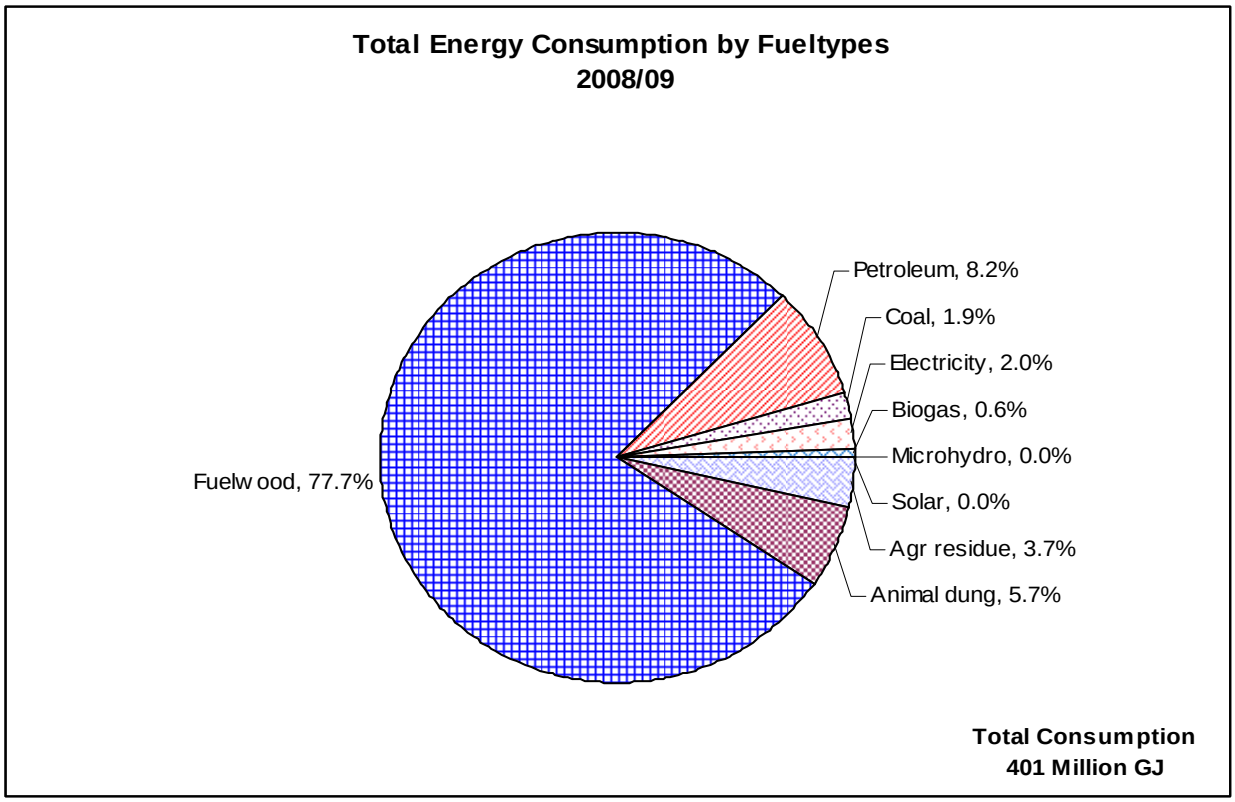
Fuelwood price for the crematory function is very subsidized in Nepal. The minimum price of fuelwood for such function is Rs. 500 per quintal (Rs. 5/kg) in Kathmandu and Pokhara and Rs. 400 per quintal (Rs. 4/kg) in Terai and Inner Teari district of Nepal. Similarly, the saling price of the fuelwood for other home and religious purposes is Rs. 700 per quintal (Rs. 7/kg) in Kathmandu and Pokhara and Rs. 600 per quintal (Rs. 6/kg) in Terai and Inner Terai districts.

Chapter 5: Energy Consumption Pattern

5.1 Energy Consumption by Fueltypes

Energy is derived from the different fuel resources which are grouped into different categories based on the fuel characteristics, monetization, resources availability, dependency etc. Nepal's energy resources are broadly divided into three categories: Traditional, Commercial and Alternative. Traditional energy resources include the all types of biomass resources used for energy production conventionally. All the energy resources with well established market prices are grouped into commercial energy category. Whereas, indigenous renewable energy resources are grouped into alternative category. Figure 5.1 shows the distribution of energy consumption by various fueltypes in 2008/09. It reveals the share of fueltypes in total energy demand system of the country. Fuelwood is the largest energy resources in Nepal providing about 77% of the total energy demand in the year 2008/09. Other sources of biomasses are agricultural residues and animal dung which contribute about 4% and 6% respectively. Share of petroleum fuels in the total energy system is about 8%. This share is somehow similar with the past few years. Other sources of commercial energy are coal and electricity both of which contributes about 4% in the total energy supply.

Figure 5.1: Share of Energy Consumption by Fueltypes



Energy consumption by various fueltypes in different economic sectors for each year since 1980/81 is given in annex 3. The total consumption is about 9% higher than the year of 2004/05 with an average growth of 2.4% annually. Table 5.1 shows the trends of total energy

consumption during 2000/01-2008/09. The overall energy consumption of Nepal is largely dominated by the use of traditional non commercial forms of energy such as fuelwood, agricultural residues and animal waste. The share of traditional biomass resources, commercial energy resources and renewable energy resources are 87%, 12% and 1% respectively. The share of traditional fuel is decreased from 91% in 1995/96, 88% in 2004/05 and 87% in 2008/09. The remaining 13% of energy consumed is through commercial source (Petroleum fuels, Coal and Electricity) and Renewable. There is a slow pace of energy shift from traditional to modern one. The share of commercial has increased from about 9% in 1995 to about 12% in 2008/09. Similarly there is a growing trend in the alternative. Within the commercial source, electricity is in the higher side in substituting other fuels.

Table 5.1 shows the total energy consumption by individual fueltypes for different years starting from 2000/01. It indicates the changes in energy consumption over the time. Total energy consumption in the country is increased by about 2.4% annually which is about in line with the present growth of GDP to some extend. However, commercial fuel consumption is increased even less than the traditional biomass resource that is 1.6% only. However, within the commercial energy system, electricity consumption is growing with an annual rate of about 10%. Coal consumption is almost similar in different years within the last decades. Its growth is just about 0.5% annually.

Table 5.1: Total Energy Consumption by Various Fueltypes and Years (Unit in 000 GJ)

Category	Fueltype	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Traditional	Agr residue	12732.1	13025.7	13326.6	13634.9	13963.5	14006.6	14370.9	14359.5	14684.7
	Animal dung	19491.8	19901.1	20319.0	20745.7	21181.4	21626.2	22080.3	22544.0	23017.4
	Fuelwood	258635.6	269157.7	274960.2	280888.3	286960.0	292460.4	298325.4	304721.2	311167.3
Traditional Total		290859.4	302084.6	308605.8	315269.0	322104.9	328093.2	334776.6	341624.7	348869.5
Commercial	ATF	2283.4	1716.3	1911.2	2316.4	2417.1	2327.0	2306.9	2493.5	2493.4
	Coal	7446.3	6481.0	5721.3	7292.4	6459.3	10364.0	6158.4	8243.0	7751.5
	Electricity	4612.1	5065.8	5433.5	5974.5	6673.2	6969.9	7658.4	8100.8	8137.2
	Fueloil	588.1	577.8	553.6	421.4	-27.7	1.2	52.8	27.2	0.0
	Gasoline	1984.1	2118.9	2259.1	2276.1	2533.6	2712.3	3413.0	3377.2	4158.4
	HSDiesel	12367.5	10856.8	11378.0	11368.7	11910.6	11163.9	11632.6	11481.6	17693.1
	Kerosene	11472.0	14017.8	12641.0	11270.6	8658.6	8217.9	7174.0	5628.1	2541.4
	LDiesel	133.7	94.4	23.9	23.1	3.4	11.4	7.0	12.0	14.8
	LPG	1974.6	2400.8	2761.3	3256.8	3820.7	3988.7	4607.0	4768.3	5702.6
	Other Petroleum	482.1	522.2	588.3	662.7	746.7	841.2	947.7	124.6	409.9
Commercial Total		43343.9	43851.9	43271.3	44862.7	43195.4	46597.3	43957.8	44256.4	48902.3
Renewable	Biogas	1179.2	1350.1	1526.5	1650.3	1847.5	2027.2	2222.1	2384.2	2593.1
	Microhydro	38.1	41.7	47.2	52.8	56.9	65.1	90.2	112.7	136.0
	Solar	0.3	0.9	1.7	2.2	2.7	2.9	3.1	4.1	5.6
Renewable Total		1217.5	1392.8	1575.5	1705.3	1907.2	2095.2	2315.4	2501.0	2734.6
Grand Total		335420.9	347329.3	353452.5	361837.0	367207.4	376785.8	381049.9	388382.1	400506.4

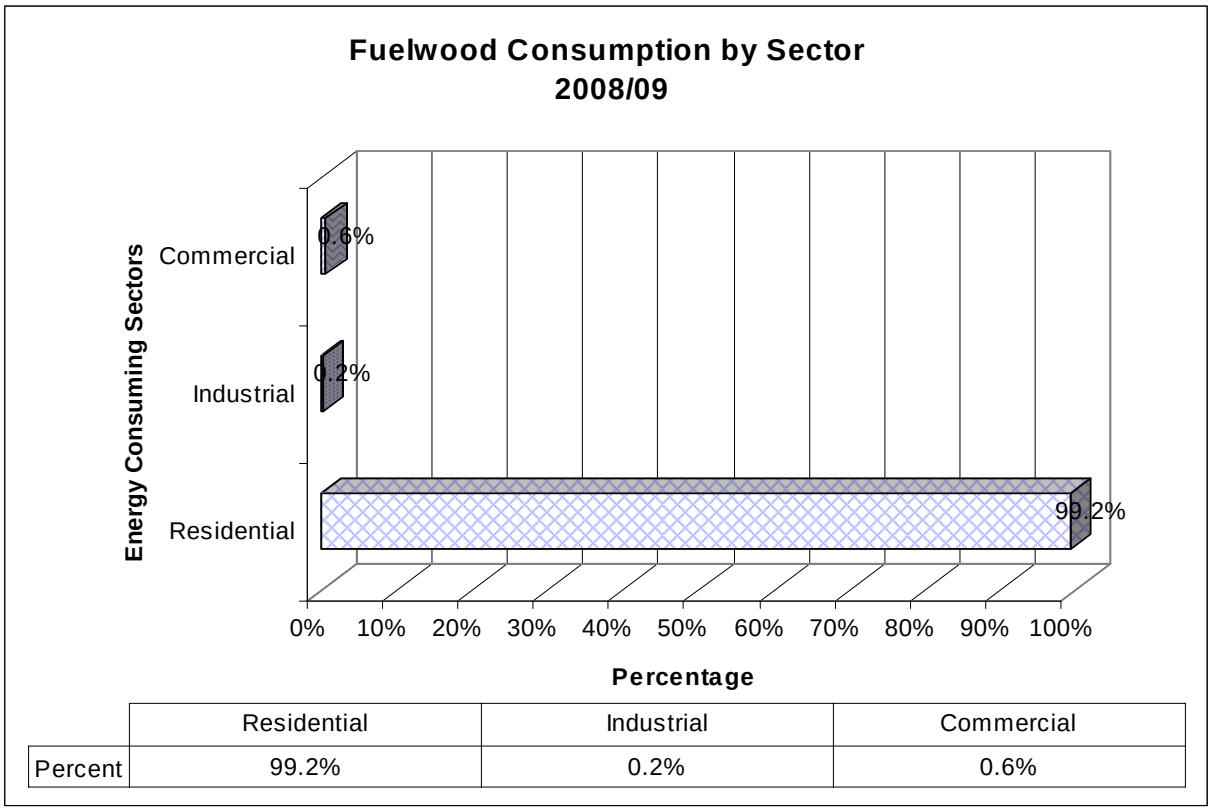
The highest growth exists in the renewable energy consumption because average annual growth is even more than 15%. Within the alternative/renewable energy system, interestingly, solar

energy consumption is being increased even more than 200% in annual basis. The average annual change in the petroleum consumption is also very low that is just about 0.7% during 2000/01 to 2008/09. Specially the consumption of kerosene, furnace oil and light diesel is decreasing whereas LPG is increasing even more than 25% annually replacing the kerosene, fuelwood and electricity as well.

5.1.1 Fuelwood Consumption by Sectors

Figure 5.2 shows the fuelwood consumption pattern by different sectors in the year 2008/09. Fuelwood consumption is about 311 million GJ which is about 77% of the total energy demand of the country. Fuelwood consumption is increasing with the decreasing rate since last decade. Average annual growth is around 2.5% which is nearly equal to the population growth of the country at national level. More than 99% of the total fuelwood is consumed only in the residential sector. Other fuelwood consuming sector are industrial and commercial. These sectors use fuelwood specially for heating, boiling and mixing with the coal.

Figure 5.2: Fuelwood Consumption by Sectors



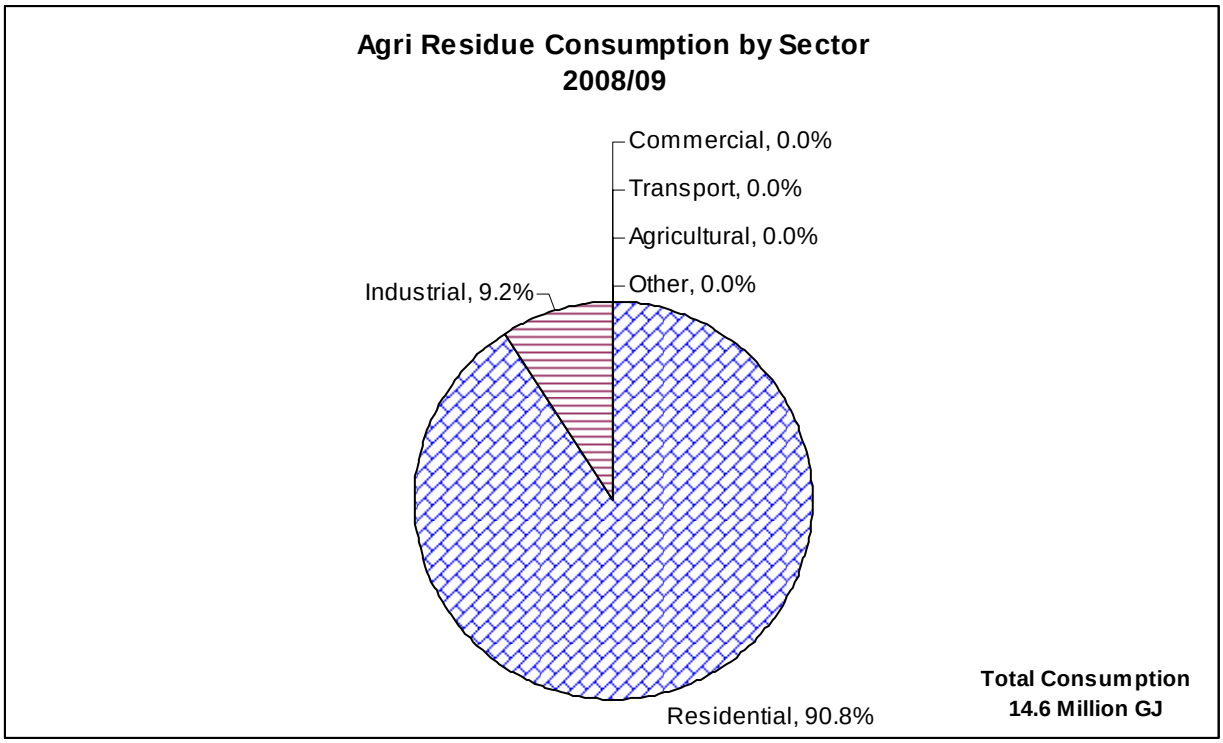
	Residential	Industrial	Commercial
Percent	99.2%	0.2%	0.6%

5.1.2 Agricultural Residue Consumption

Agricultural residue is the third largest fueltypes providing energy specially in residential and industrial sectors. Total agricultural residue consumption in the year 2008/09 was about 14.6 million GJ which is about 4% of the total energy demand of the same year. Most of the residues are used in residential sector in different form. Generally such residues are used for igniting the wood fuels while mixing with the wood fuel resources. Near about 10% of the total residues are

consumed in industrial sector for heating and boiling purposes. Rice husk is one of the major fuels in many industries that require heat for its operation.

Figure 5.3: Consumption of Agricultural Residues by Sectors



Agri residue consumption is growing by about 1.9% annually with the decreasing rate. Due to the poor form of fuel, commercial sector don't use it.

5.1.3 Animal Dung Consumption

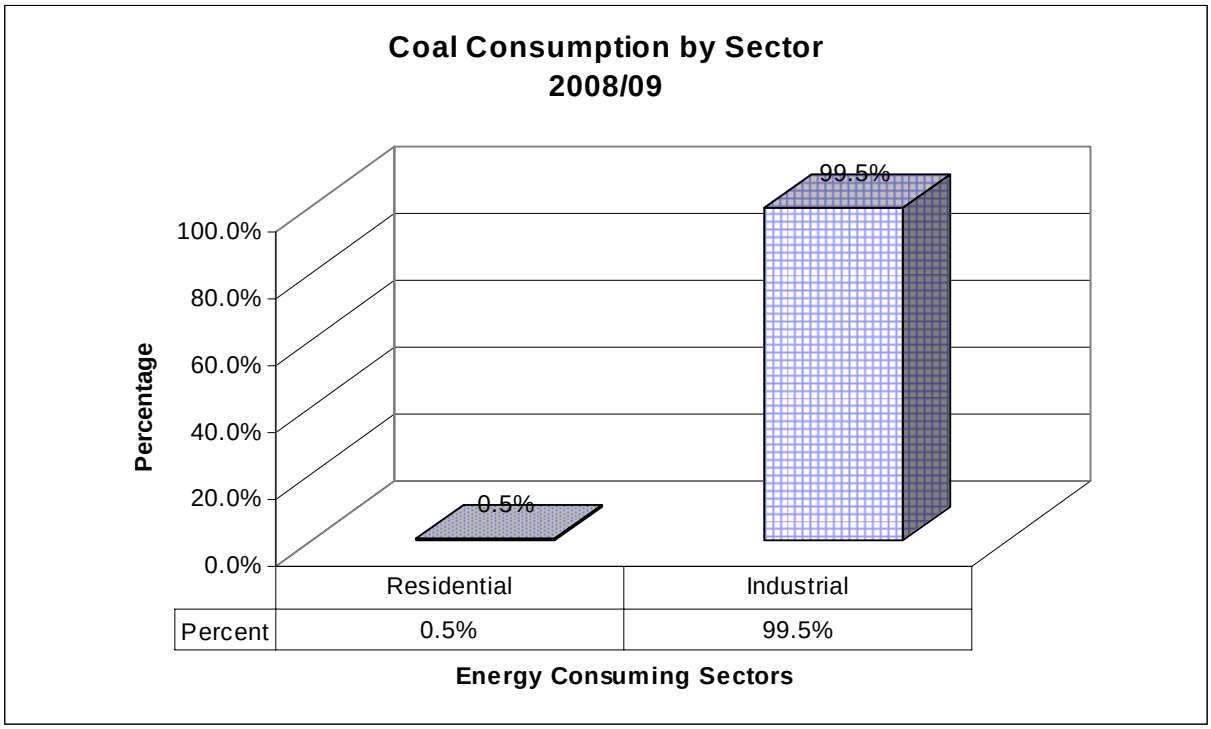
Animal dung is consumed only in the residential sector so far. However, its contribution is very high in the total energy system because it supplies about 6% of the total demand annually. Animal dung is widely used in the Terai region of the country where forest resources are not easily available either due to distance or due to reachability factor. Animal dung is being used in both form that are dry cake and gaseous. To make the dry cake from animal dung generally it is mixed with the soft wood components coming from wood waste, shrubs and herbaceous plants such as rice stalk. This fuel is the poorest form of energy while looking from energy ladder perspective. Growth of animal dung is also high that is around 2.3% annually. However, use of animal dung in biogas generation is being increased by about 15% in annual basis.

5.1.4 Coal Consumption

Coal is one of the important energy resources for Nepal because it provides more than half of the total energy requirement of the industrial sector in the country. It is almost used in industrial sector and very minimal amount is used in residential and some time in commercial sector as well. In many cases, residential sector and commercial sectors can't be distinguished because

same owner doesn't keep the account of energy consumption separately for residential and commercial business. This generally happens with small and medium scale shop businesses.

Figure 5.4: Coal consumption by sector (2008/09)



Only about 0.5% is used in residential sector and remaining part is used in industrial purpose. This resource provides heating and boiling services in the industries. In the earlier years, it was also used for railway transport in Janakpur-Jaynagar corridor.

5.1.5 Electricity Consumption by Sectors

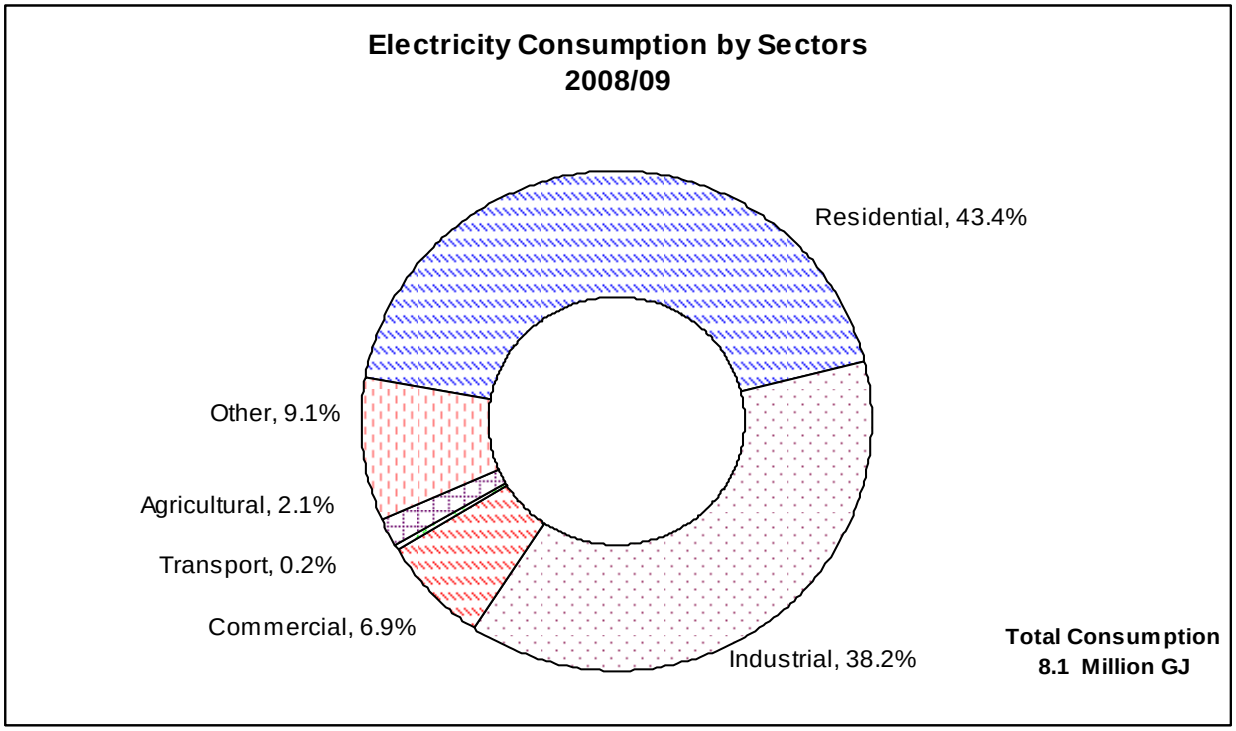
With the increasing growth rate of customers availing electricity services of NEA, the power and energy demand is also increasing accordingly. In 2007/08, the numbers of customers grew by 9.07% as compared to that of previous year. Accordingly the power and energy demand also grew by 11.31% and 10.76% respectively in that year. This growth is more significant in residential and industrial sector and a little less in other development sectors (NEA, 2009).

Electricity in the residential sector is mainly used for lighting. However, depending upon the degree of urbanization, it is also increasingly used for running domestic appliances. They include from the most basic electrical / electronic appliances such as radios, TVs irons to modern equipment like rice cookers , geezers, computers, modern audio- visuals, refrigerators, air conditioners, vacuum cleaners etc. All together 1.0% of total residential energy consumption was met by electricity in 2008/09. With the growing rate of migration from rural to urban areas, the use of electricity in the residential sector, in the past has increased very sharply in the urban areas. This has been further aggravated from the facts that most of the people with higher socio-economic strata equipped with modern electrical appliances resides in these parts of the country.

The total energy consumption in the residential sector of urban areas is increasing more rapidly than the one in rural areas.

Out of 48% of population having access to electricity, only 8% of people of rural areas enjoy it (MoF, 2007). This is clearly seen from the percentage of rural electrification that has been materialized so far. Most of the electricity connected to rural areas is used for the residential purposes and that also mainly for lighting. The other uses being running radios, TVs and to some extent cooking and water heating. Exact figures on the amount of electricity being used for various residential purposes are not available.

Figure 5.5: Electricity Consumption by Sector

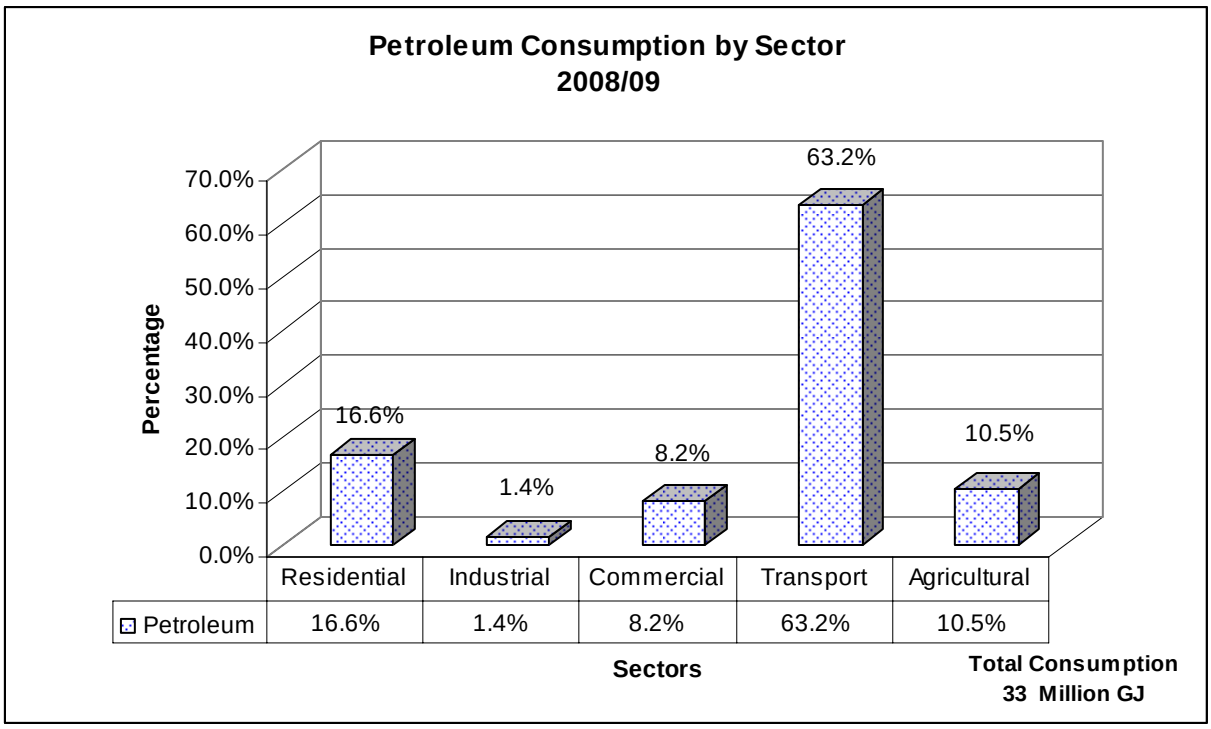


The industrial sector share of energy consumption is about 3.5% of the total energy consumption in Nepal, taking thus the third place after residential sector and transport sector so far as the share of sectoral consumption is concerned. More than half of this energy requirement is met by coal followed by electricity (23%). The main end uses of electricity in this sector are motive power, heating and lighting. The share of energy consumption in the transport sector comes to about 5.2% of the total energy consumption in Nepal. The contribution of electricity in these sectors is minimum and comes to about 0.1% only. It is used mainly to run cable cars, ropeways ad trolley buses, which are very few in the country. Presently commercial sectors consume around 1.3 % of the total energy supply in Nepal. The consumption, however, is in increasing trend.. The share of electricity consumption in this sector is minimum i.e. about 11%. The main uses of electricity in commercial sector, is similar to those in residential sectors, e.g. cooking , heating , lighting , water pumping and running other electrical appliances. The share of energy consumption in agriculture sector is about 1.0% of total energy consumption. Out of that, 5% is borne by electricity. The only other fuel being used in this sector is high speed diesel (95%). Electricity, in this sector, is used mainly for lift irrigation.

5.1.6 Petroleum Consumption by Sectors

Petroleum is the second largest energy fuel only after fuelwood because it supplies about 8% of the total energy demand of the national economy. This fuel has significant role in economic development processes. Because, three major economic sectors namely the transport, commercial and Industrial output is mostly depended on this fuel resources which are considered as the productive sector. Figure 5.6 gives the petroleum consumption by different sector.

Figure 5.6: Petroleum consumption by Sector



About 63% of the total petroleum consumption is occurred in the transport sector . Mostly the transport vehicles use this fuel such as road transport and air transport. However, its contribution in the transport sector is almost 100%. Very nominal amount of electricity is used in transport purpose specially by trolly bus in Kathmandu. About one quarter of the petroleum is utilized in residential sector and agricultural sector together. LPG and Kerosene is widely used in residential sector whereas diesel fuel is used in agricultural sector for tractor and water pumping purpose.

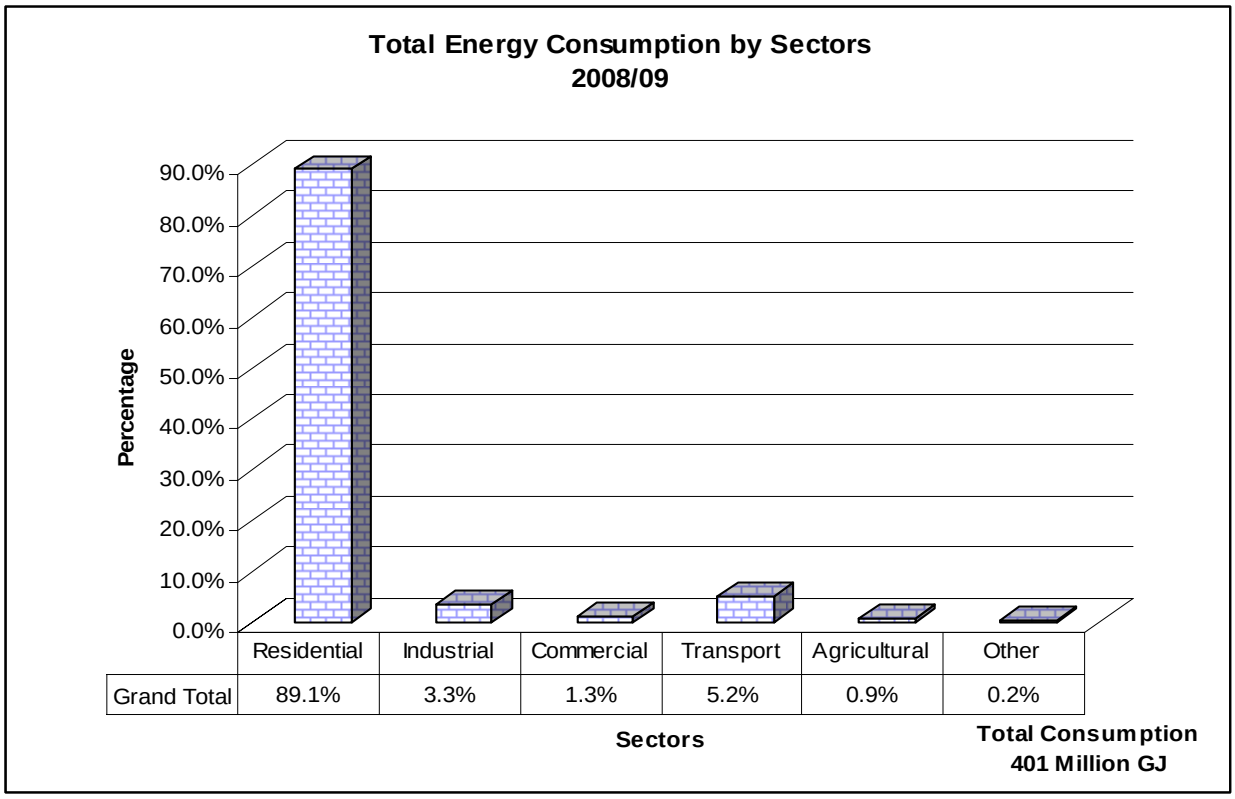
5.2 Sectoral Energy Consumption

The energy consuming sectors has been defined as per the economic sector of the country. They are residential, commercial, transport, industrial and agriculture sector. For energy accounting, others have been included as energy consuming entity which does not fall in the above five sectors, are included in others like street light, temples, mosques, church etc. The total energy consumption in the same year was 401 million GJ. The sectoral energy consumption for the year 2008/09 has changed only marginally as compared to the previous years. However, the sectoral energy consumption for the year 2008/09 has increased by about 9% as compared to the 2004/05

years. Figure 5.7 shows the different share of energy consumption by various sectors in 2008/09. The figure shows that the residential accounts for the major share of energy consumption (89.1%), followed by transport (5.2%), industry (3.3%), commercial (1.3%) and then the agricultural and others.

WECS has been putting in effort in analyzing and maintaining data on sectoral energy consumption by fuel type and end use. Table 5.2 shows the historical trend of energy consumption by these sectors since 2000/01. In Nepal, due to inadequate nos. of energy intensive industries, Industrial sector come in the third position in the total energy consumption.

Figure 5.7: Sectoral Energy Consumption in Nepal (2008/09)



It can be observed that share of residential sector in the total energy consumption is decreasing in a steady pace, while others sectors have a little shift from the previous years. In Nepal, due to inadequate numbers of energy intensive industries, industrial sector comes in the third position in the total energy consumption. Detailed break-down of energy consumption of fuel type for each sub sectors are discussed in the subsequent sections. Table 5.2 shows the historical trend of sectoral energy consumption in Nepal.

Table 5.2: Historical trend of sectoral energy consumption in Nepal

Unit in 000 GJ

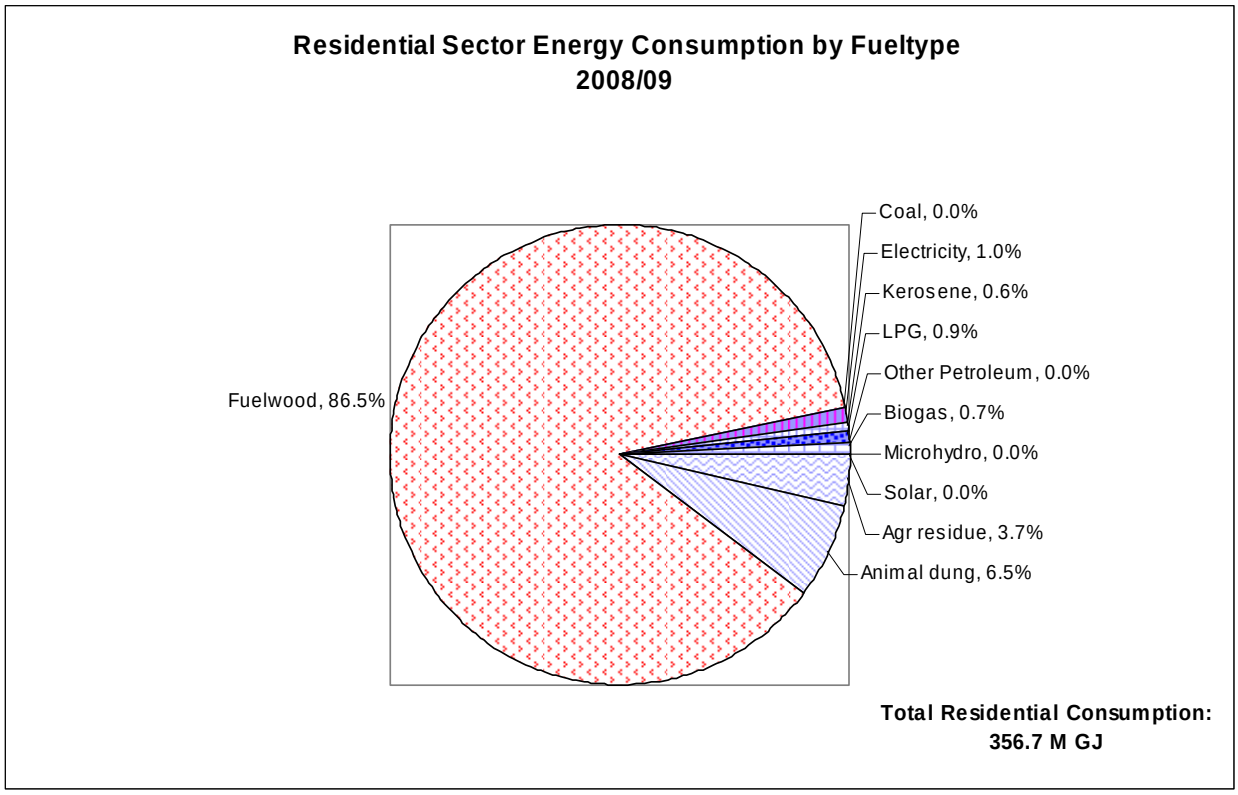
Sector	Years								
	200001	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Residential	301142.9	314615.8	320180.1	326248.0	331520.5	337627.5	345384.3	351191.9	356752.1
Industrial	12998.3	12537.0	11969.5	13715.9	12761.3	16839.8	12791.4	13988.7	13369.8

Commercial	4127.6	4921.3	5228.1	5316.1	5335.0	5336.4	4673.8	4885.7	5122.2
Transport	13591.5	12024.6	12702.8	13132.0	13894.2	13469.5	14509.5	15036.6	20876.0
Agricultural	3152.0	2776.2	2888.0	2891.7	3084.7	2888.5	3010.6	2520.8	3646.4
Other	408.5	454.4	484.0	533.3	611.6	624.1	680.3	758.4	739.9
Grand Total	335420.9	347329.3	353452.5	361837.0	367207.4	376785.8	381049.9	388382.1	400506.4

5.2.1 Residential Sector Energy Consumption

The residential sector consumed almost 89% of the total energy consumption of Nepal in 2008/09. This sector used about 356.7 million GJ (89.1%) in the same year. Biomass resources are the major fuels used in this sector, namely fuel-wood, agricultural residue and the animal waste. Recently renewable sources like biogas and electricity from micro-hydro and solar home systems are substituting conventional fuels used mainly for cooking and lighting. The commercial sources of fuel used are nominal in amount and is mainly used in the urban centers.

Figure 5.8: Presents the share of different fuels used in the residential sector



Fuelwood alone supply 86% of the total energy requirement of the sector followed by animal dung, agri residue and petroleums respectively. Share of alternative energy resources is still quite insignificant having less than 1% contribution.

Residential sector energy consumption is the function of number of household and population. The population growth rates as well as the economic situation of the household are used as the main driver for the types of fuel and energy consumption in the residential sector of Nepal.. In

the residential sector, the energy used for mainly cooking, heating, animal feed preparation, lighting etc.

Residential sector is broadly divided into two categories namely the rural residential and urban residential. WECS (2006) has assessed 47.7 million GJ energy consumption in the urban residential which is equivalent to about 14.5% of the total residential energy consumption. Urban sector energy consumption pattern is little different than the rural residential. About 52% of the urban energy is used for cooking purpose followed by electric appliance (14%), Lighting (13%), heating and cooling (10%), animal feeding (8%) and agricultural processing (3%). Unlike in the rural residential, fuelwood share in urban residential is less (29%). Contribution of fuelwood and electricity is almost equal (29%) whereas LPG contributes about 25% of the total consumption of the sub sector followed by kerosene (9%), animal residue and dung (3% each) and biogas (2%).

It has been observed that the LPG is substituting as a cooking fuel in the urban centres as the consumption growth rate of LPG is about 23% per annum for the last few years followed by electricity with 10 percent. Though the consumption of renewable is nominal in quantitative terms, the annual growth rate of solar is quite high with more than 200% followed by biogas and electricity from micro-hydro with 15% and 32% respectively. There is a very high decreasing trend in the use of kerosene in the residential sector. The overall growth rate of energy consumption in the residential sector is about 2.3 % per annum.

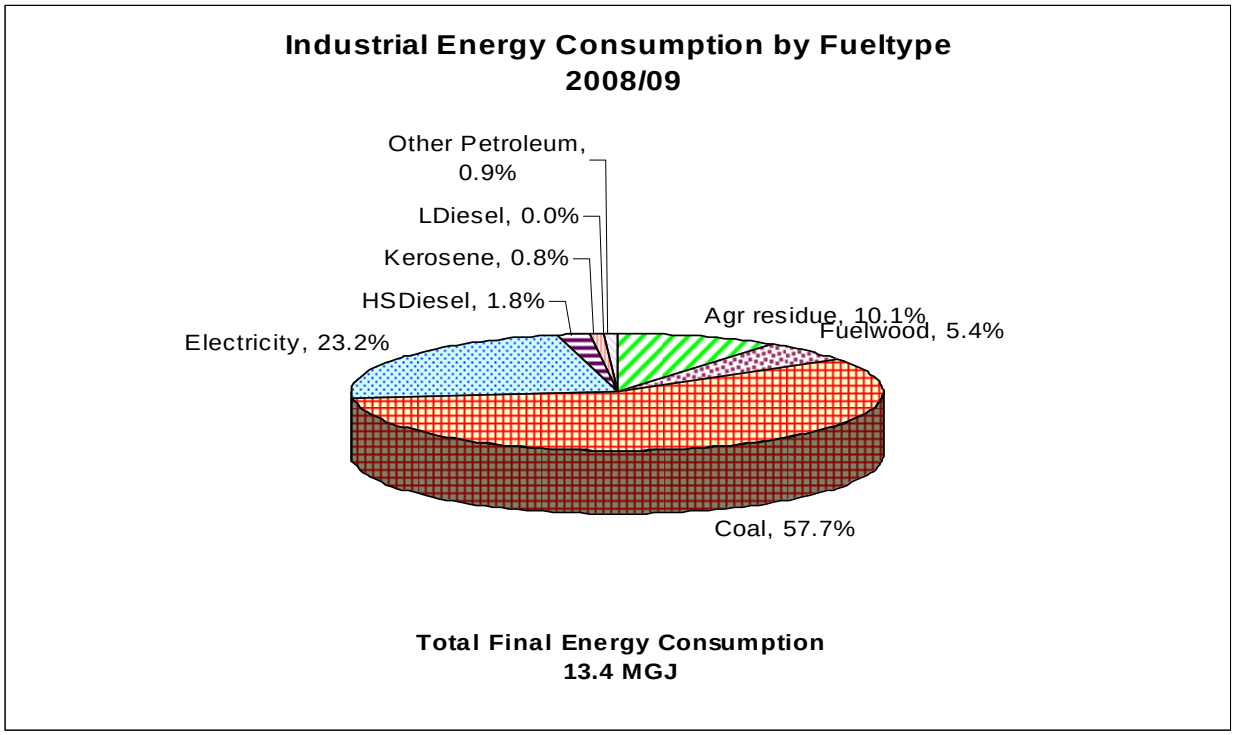
5.2.2 Industrial Sector Energy Consumption

Figure 5.9 shows the industrial energy consumption by fueltype for the year 2008/09. Total Energy consumption in this sector is about 13.4 million GJ which is about 3.3% of the total energy deamnd. The energy consumption has been increasing marginally during the last few years. The industrial energy consumption has increased only by about 0.4% annually since last eight years. The main end uses in the industrial sector are process heating, motive power, boiling in the boilers and lighting.

WECS (1998) has assessed the industrial sector energy consumption pattern both in traditional and modern sector. Industrial energy consumption was 9.1 million GJ for the year 1996/97 which increased by about 3.9% annually during the period. Industrial sector is broadly categorized into two types; modern and traditional. Modern industries are also grouped into large industry and medium industry.

The share of energy consumption in large modern industry is about 78%, followed by medium industry (17%) and traditional industry (5%). Industrial energy consumption by physiographic region shows very dissimilar figure. Because 63% of the total sector energy is consumed in Terai region alone whereas 29% in Hills and only 8% is consumed in Mountain districts. Regarding end use energy consumption in the sector, it is dominated by Boiler that is why coal is heavily consumped in this sector. Other main end uses of the sectors are power motive (31%), process heating (30%) and lighting (2%).

Figure 5.9: Indsustrial Energy Consumption by Fueltypes



Many traditional and small scale industries are being closed due to inability to compete with the international goods. This trend seems to be continued in the near future as well. Insufficient and unreliable supply of energy particularly the electricity has affected the industries to close. Electricity provides nearly one forth of the total industrial energy consumption. Uses of electricity are mostly for power motives and lighting in this sector. Uses of petroleum in this sector are just about 3.5%. This petroleum is used for captive generation in most cases. Coal supplies more than half of the total industrial energy specially for heating purpose using in boiler and kiln. Biomass resources, particularly the fuelwood and agricultural residue, are still being used in industrial sector for ignition of fire as well as for heating purposes, sometime together with coal. Biomass still supplies about 15% of the industrial energy requirement.

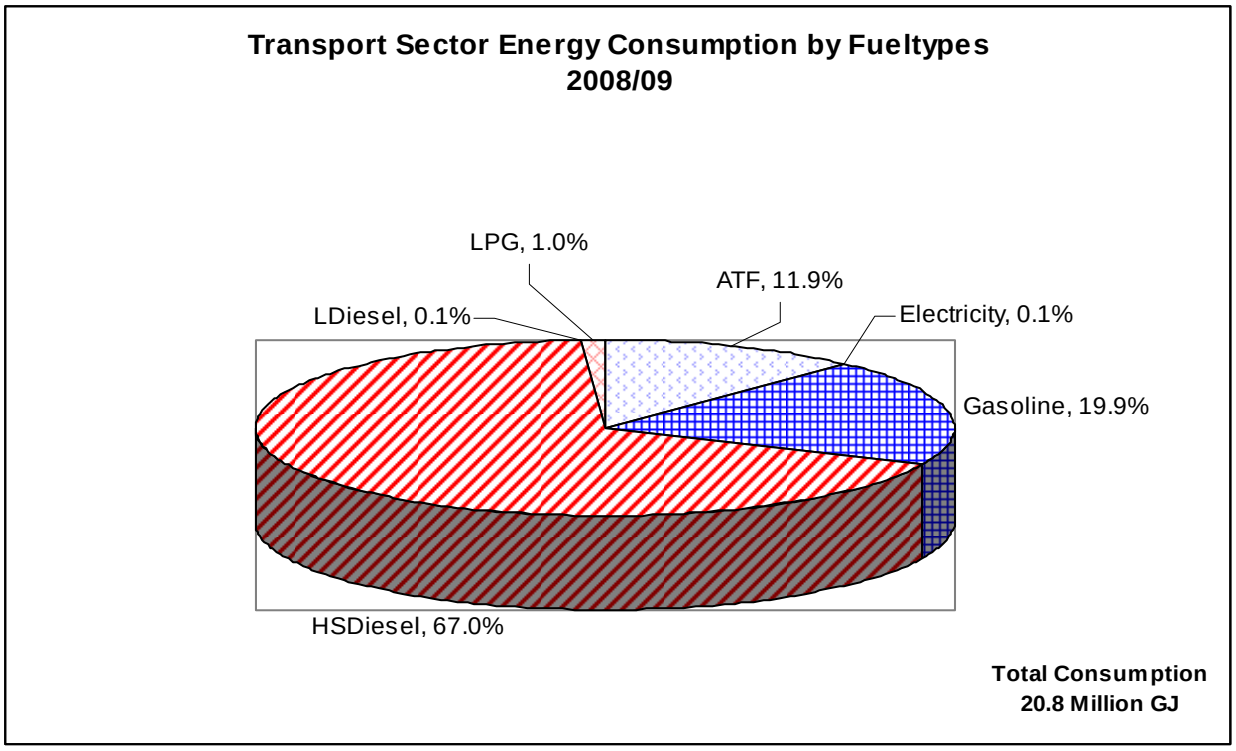
5.2.3 Transport Sector Energy Consumption

Transport is the second largest energy consuming sector only after the domestic sector. Energy consumption in this sector is about 20.8 million GJ (5.2%) in the year 2008/09. The total energy consumption in the transport sector has been in the increasing trend. It has been seen that for the past few years the energy consumption growth rate in this sector is about 8.9 % annually. Figure 5.10 shows the consumption of different fuels in this sector during the same year. The details are presented in the Annexes.

It is found that High Speed Diesel takes the highest share with 67% followed by Motor Spirit with about 20% and then Air Turbine Fuel with 12%. The contribution of LPG is also increasing

in this sector providing about 1% energy requirement of this sector. And electricity consumption in this sector is very minimal. There is a little shift in the energy consumption pattern in Transport sector than the the year 1999/2000. WECS (2000) has identified about 78.8% use of High Speed Diesel in the transport sector followed by ATF (13.4%), Motor Spirit (11.4%), LPG (0.3%) and Grid electricity (0.2%) respectively.

Figure 5.10: Transport Sector Energy Consumption by Fueltypes



Transport sector can be divided into five categories while assessing the energy consumption which are namely the Road transport, Railway transport, Trolly transport, Ropeway transport and Aviation transport. Energy consumption by sub sector of this transport sector is heavily dominated by Road because it consumes about 86.5% of the total sectoral consumption whereas Aviation subsector consume about 13.4%. Consumption in Railway, Trollybus, Ropeway sub sector is very minimal even less than 0.5%.

5.2.4 Commercial Sector Energy Consumption

Commercial sector is one of the badly affected economic sectors during the last decades. Energy consumption in this sector is increasing at an annual rate of 3% since 2000/01. This sector includes large number of other sub sectors namely the Academic (school, college, university), Health (health post, hospitals), Institutions (Private and Publics), Retail shops (essential, non essential), Hotels (Star hotels, Non star hotels, Restaurant, Cinema/Hi-vision halls, Water supply, Military and Police barrack and Others (Public lighting, Religious place etc). Total energy consumed in this sector was about 5.2 million GJ only in 2008/09 which is slightly less than the commercial energy consumption of 2004/05. The main fuels used in the commercial sector are petroleum (LPG and Kerosene), fuelwood, and electricity. The main end-uses of the commercial

sector are quite similar to that of residential sector such as cooking, heating, lighting, boiling, cooling, water pumping and electric appliances etc.

Figure 5.11: Commercial Sector Energy Consumption by Fueltypes

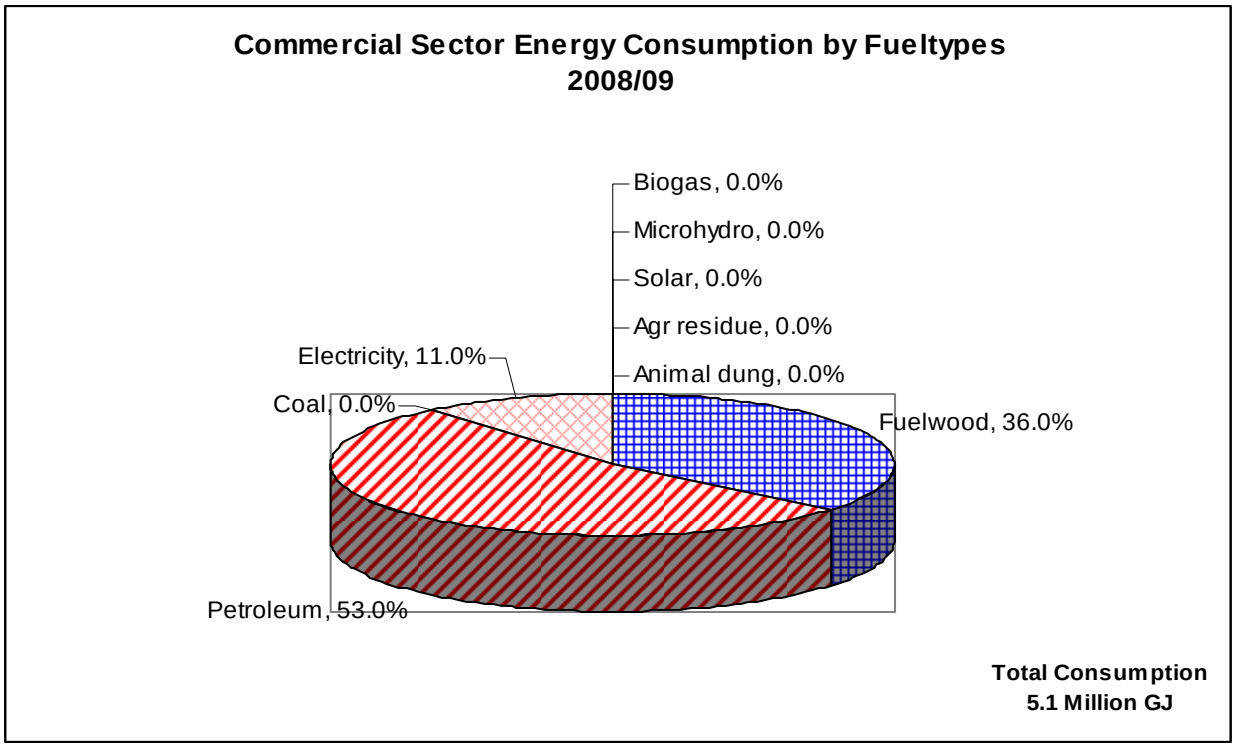


Figure 5.11 presents the different share of fuel types consumed in the commercial sector. The largest contribution comes from petroleum specially the LPG and Kerosene Providing about 53% of the sector demand. Then fuelwood stands for supplyling about 36% of the sectoral energy consumption. Electricity is the third largest sources of energy (11%) in the sector. For the last few years, it has been seen that the LPG consumption growth rate in this sector is about 22%, while the change rate of kerosene is in the decreasing trend (9% per annum). Fuelwood and electricity consumption is increasing by about 2.1% and 9% per annum respectively in this sector.

Cooking is the largest end use in this sector consuming about 68.4% of the total followed by lighting (19.3%), boiling water (0.3%), space heating and cooling (5.3%) and other electrical services such as water pumping etc.(6.7%) .

5.4.5 Agricultural Sector Energy Consumption

Agricultural sector uses only two types of energy sources that are electricity and petroleum. Human and animal draft power are not considered in this sectoral energy demand since it is very difficult to assess. In the year 2008/09, agricultural sector consume only about 1% of the total national energy demand (3.6 Million GJ). Table 5.3 shows the agricultural sector energy consumption by fueltypes in the same year. About 95% of the total agricultural energy comes from petroleum products specially the diesel fuel. Only 5% is derived from electricity.

Table 5.3: Agricultural Sector Energy Consumption by Fueltypes

Fueltype	Consumption (000 GJ)	Percent
Electricity	173.7	4.8%
HSDiesel	3469.0	95.1%
LDiesel	3.7	0.1%
	3646.4	100.0%

Electricity consumption in this sector is increasing at higher rate compared to the petroleum. It is increasing by about 8% annually since 2000/01 whereas light diesel oil is increasing by about 11% annually. Average rate of change in high speed diesel consumption is just around 1% only.

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Annexes

Annex 1

Conversion Factors and Energy Content

Basic Energy Conversion

Units	Kcal (000)	GJ	TCE	TOE
Kilo Calori	1.0000	0.0041868	0.0001429	0.0000972
GJ	238.8459	1.0000000	0.0341208	0.0234622
TCE	7000.00	29.3076000	1.0000000	0.0687622
TOE	10290.00	42.6217000	1.4542880	1.0000000

Energy Contents of Various Fuel Type

Fueltype	Unit	Kcal (000)	GJ	TCE	TOE	Other	
Traditional Fuel							
Fuelwood	tonne	4000	16.75	0.57	0.39	1.43	m3
	m3	2800	11.72	0.4	0.27	0.7	tonne
Charcoal	tonne	7100	29.73	1.01	0.69	2.86	m3
	m3	2485	10.4	0.36	0.24	0.35	tonne
Agricultural Waste	tonne	3000	12.56	0.43	0.29		m3
	m3						tonne
Animal Dung*	tonne	2600	10.89	0.37	0.25		m3
	m3						tonne
Biogas	000 m3	5800	23	0.83	0.56		
Commercial Fuel	Unit	Kcal (000)	GJ	TCE	TOE	Others	
Coal	tonne	6000	25.12	0.86	0.58		
	kl		30.08			0.611	tonne
LPG	tonne	11760	49.24	1.68	1.14	1.637	KL
	kl	8000	33.49	1014	0.78	0.71	tonne
MS	tonne	11290	47.27	1.61	1.1	1.41	kl
	kl	8640	36.17	1.23	0.84	0.78	tonne
ATF	tonne	11130	46.60	1.59	1.08	1.29	kl
	kl	8660	36.26	1.24	0.84	0.78	tonne
KRS	tonne	11130	46.06	1.59	1.08	1.29	kl
	kl	9060	37.93	1.29	0.88	0.83	tonne
HSD	tonne	10960	45.89	1.57	1.07	1.21	kl
	kl	9350	39.15	1.34	0.91	0.85	tonne
LDO	tonne	10960	45.89	1.57	1.07	1.17	kl
	kl	9860	41.28	1.41	0.96	0.93	tonne
FO	tonne	10560	44.21	1.51	1.03	1.07	kl
Electricity	MWh	860	3.6	0.12	0.08	5.78	GHh from oil

* dry basis, One tonne of dung yields 190 cubic meter of biogas at 15 degree Centrigrade

Annex 2

Table 2.1: Land use distribution by Development Regions (1978/79)

Landuse type	EDR	CDR	WDR	MWDR	FWDR	Grand Total
Forest	33.2%	40.4%	31.5%	38.5%	50.9%	38.1%
Shrubland	6.7%	8.2%	4.7%	1.9%	3.1%	4.7%
Grassland	6.2%	5.2%	14.9%	18.3%	11.1%	11.9%
NCI	8.3%	8.6%	7.7%	4.1%	5.7%	6.7%
Cultivated land	29.4%	28.9%	20.2%	10.6%	15.1%	20.1%
Otherland	16.1%	8.7%	21.1%	26.6%	14.1%	18.5%
Grand Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 2.2: Accessibility of Forest land by Altitude Classes and Dev Region (1994)

Unit in 000 ha

Altitude classes (m.)	Development Regions					Nepal
	FWDR	MWDR	WDR	CDR	EDR	
0-500	160.7	210.3	111.2	229.8	147.3	853.3
501-1000	54.4	114.0	31.9	88.3	76.1	364.8
1001-1500	56.6	54.0	37.4	47.1	102.9	298.0
1501-2000	67.5	24.0	15.3	66.3	72.8	245.9
2001-2500	19.6	24.0	24.9	38.5	70.2	177.1
2501-3000		18.0	33.1	52.2	73.6	176.9
>3000		10.0	8.3	5.5	33.4	57.2
Total	358.8	454.4	262.1	527.7	576.3	2179.3

Table 2.3: Distribution of CF by development region and physiographic region

Dev Region	Phy Region			Grand Total
	Terai	Hills	Mountain	
FWDR	1.2%	8.5%	5.2%	14.9%
MWDR	6.7%	11.4%	3.6%	21.7%
WDR	1.0%	13.4%	0.5%	15.0%
CDR	2.0%	14.8%	4.6%	21.3%
EDR	2.9%	19.6%	4.6%	27.1%
Grand Total	13.8%	67.6%	18.6%	100.0%

Table 2.4: Sustainable Annual Fuelwood Supply from Nepal's Natural Forests (1985/86)

Prod in 000 ton

Region	Annual Yield (ton/ha)	Gross Supply	Accessible Supply from		Forest &Shrub
			Forests	Shrubland	
High Himal	2.2	345	18	124	142
High Mountains	2.7	4438	916	45	961
Middle Mountains	2.1	3725	2138	193	2331
Siwaliks	3.7	5293	791	7	798
Terai	5.9	2635	2635	20	2655
Total	3	16436	6498	389	6887

Table 2.5:Agricultural Residue Production by Regions (2008/09)

Unit in 000 tons

Dev. Region	Phy. Region			Grand Total
	Hills	MNT	Terai	
EDR	361.7	1436.9	3179.2	4977.8
CDR	357.5	1662.7	3939.7	5960.0
WDR	10.4	2448.1	2069.5	4528.1
MWDR	109.1	952.1	1373.7	2434.9
FWDR	141.1	296.7	1073.4	1511.2
Grand Total	979.7	6796.6	11635.5	19411.8

Table 2.6: Agricultural Residue Production by Crops and Region (Percent)

Crops	Dev. Region					Grand Total
	EDR	CDR	WDR	MWDR	FWDR	
Paddy	14.2%	13.9%	10.2%	5.1%	3.8%	47.3%
Wheat	2.1%	4.3%	2.6%	1.9%	1.2%	12.1%
Maize	6.5%	6.1%	7.0%	3.7%	1.3%	24.6%
Millet	0.7%	0.6%	1.0%	0.2%	0.1%	2.6%
Barley	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%
Oil seed	0.2%	0.4%	0.1%	0.3%	0.2%	1.2%
Grain legumes	0.9%	1.7%	0.6%	1.0%	0.4%	4.6%
Jute	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%
Sugarcane	0.9%	3.5%	1.7%	0.3%	0.7%	7.2%
Grand Total	25.6%	30.7%	23.3%	12.5%	7.8%	100.0%

Table 2.7: Physiographic categories of the district in Nepal

Development Region	Physiographic Region	Districts
EDR	Mountain region	Sankhuwasabha, Solukhumbu, Taplejung
	Hilly region	Bhojpur, Dhankuta, Ilam, Khotang, Okhaldhunga, Panchthar, Terhathum, Udaypur
	Terai region	Jhapa, Morang, Saptari, Siraha, Sunsari
CDR	Mountain region	Dolakha, Rasuwa, Sindhupalchowk
	Hilly region	Bhaktapur, Dhading, Kathmandu, Kavre, Lalitpur, Makawanpur, Nuwakot, Ramechhap, Sindhuli
	Terai region	Bara, Chitwan, Dhanusa, Mahaottari, Parsa, Rautahat, Sarlahi
WDR	Mountain region	Manang, Mustang
	Hilly region	Argakhanchi, Baglung, Gorkha, Gulmi, Kaski, Lamjung, Myagdi, Palpa, Parbat, Syanja, Tanahu
	Terai	Kapilbastu, Nawalparasi, Rupandehi
MWDR	Mountain region	Dolpa, Humla, Jumla, Mugu, Kalikot
	Hilly region	Dailekh, Jajarkot, Pyuthan, Rolpa, Rukum, Salyan, Surkhet
	Terai region	Dang, Banke, Bardia
FWDR	Mountain region	Bajhang, Bajura, Darchula
	Hilly region	Accham, Baitadi, Dadeldhura, Doti
	Terai region	Kailali, Kanchanpur

Annex 3

Energy Consumption in 2008/09

Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	13334.5	1350.3	0.0	0.0	0.0	0.0	14684.7
	Animal dung	23017.4	0.0	0.0	0.0	0.0	0.0	23017.4
	Fuelwood	308604.3	721.1	1841.9	0.0	0.0	0.0	311167.3
Traditional Total		344956.1	2071.4	1841.9	0.0	0.0	0.0	348869.5
Commercial	ATF	0.0	0.0	0.0	2493.4	0.0	0.0	2493.4
	Coal	35.1	7716.4	0.0	0.0	0.0	0.0	7751.5
	Electricity	3534.3	3106.6	563.3	19.3	173.7	739.9	8137.2
	Furnace oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Gasoline	0.0	0.0	0.0	4158.4	0.0	0.0	4158.4
	HSDiesel	0.0	240.9	0.0	13983.2	3469.0	0.0	17693.1
	Kerosene	2126.6	111.2	303.6	0.0	0.0	0.0	2541.4
	LDiesel	0.0	0.2	0.0	10.8	3.7	0.0	14.8
	LPG	3201.4	0.0	2290.4	210.8	0.0	0.0	5702.6
	Other Petroleum	163.9	123.0	123.0	0.0	0.0	0.0	409.9
Commercial Total		9061.3	11298.4	3280.3	20876.0	3646.4	739.9	48902.3
Renewable	Biogas	2593.1	0.0	0.0	0.0	0.0	0.0	2593.1
	Microhydro	136.0	0.0	0.0	0.0	0.0	0.0	136.0
	Solar	5.6	0.0	0.0	0.0	0.0	0.0	5.6
Renewable Total		2734.6	0.0	0.0	0.0	0.0	0.0	2734.6
Grand Total		356752.1	13369.8	5122.2	20876.0	3646.4	739.9	400506.4

Energy Consumption in 2007/08
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	13020.1	1339.4	0.0	0.0	0.0	0.0	14359.5
	Animal dung	22544.0	0.0	0.0	0.0	0.0	0.0	22544.0
	Fuelwood	302251.5	717.5	1752.1	0.0	0.0	0.0	304721.2
Traditional Total		337815.6	2057.0	1752.1	0.0	0.0	0.0	341624.7
Commercial	ATF	0.0	0.0	0.0	2493.5	0.0	0.0	2493.5
	Coal	36.8	8206.3	0.0	0.0	0.0	0.0	8243.0
	Electricity	3352.9	3243.9	555.8	21.2	168.7	758.4	8100.8
	Fueloil	0.0	27.2	0.0	0.0	0.0	0.0	27.2
	Gasoline	0.0	0.0	0.0	3377.2	0.0	0.0	3377.2
	HSDiesel	0.0	165.8	0.0	8966.8	2349.1	0.0	11481.6
	Kerosene	4722.3	250.9	654.8	0.0	0.0	0.0	5628.1
	LDiesel	0.0	0.2	0.0	8.8	3.0	0.0	12.0
	LPG	2713.5	0.0	1885.6	169.2	0.0	0.0	4768.3
	Other Petroleum	49.8	37.4	37.4	0.0	0.0	0.0	124.6
Commercial Total		10875.3	11931.7	3133.6	15036.6	2520.8	758.4	44256.4
Renewable	Biogas	2384.2	0.0	0.0	0.0	0.0	0.0	2384.2
	Microhydro	112.7	0.0	0.0	0.0	0.0	0.0	112.7
	Solar	4.1	0.0	0.0	0.0	0.0	0.0	4.1
Renewable Total		2501.0	0.0	0.0	0.0	0.0	0.0	2501.0
Grand Total		351191.9	13988.7	4885.7	15036.6	2520.8	758.4	388382.1

Energy Consumption in 2006/07
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	13007.1	1363.8	0.0	0.0	0.0	0.0	14370.9
	Animal dung	22080.3	0.0	0.0	0.0	0.0	0.0	22080.3
	Fuelwood	295994.3	716.2	1614.9	0.0	0.0	0.0	298325.4
Traditional Total		331081.7	2079.9	1614.9	0.0	0.0	0.0	334776.6
Commercial	ATF	0.0	0.0	0.0	2306.9	0.0	0.0	2306.9
	Coal	26.9	6131.5	0.0	0.0	0.0	0.0	6158.4
	Electricity	3215.8	3056.9	510.1	22.7	172.7	680.3	7658.4
	Fueloil	0.0	52.8	0.0	0.0	0.0	0.0	52.8
	Gasoline	0.0	0.0	0.0	3413.0	0.0	0.0	3413.0
	HSDiesel	0.0	194.5	0.0	8601.9	2836.2	0.0	11632.6
	Kerosene	6055.7	328.0	790.3	0.0	0.0	0.0	7174.0
	LDiesel	0.0	0.1	0.0	5.1	1.8	0.0	7.0
	LPG	2688.7	0.0	1758.4	159.9	0.0	0.0	4607.0
	Other Petroleum	0.0	947.7	0.0	0.0	0.0	0.0	947.7
Commercial Total		11987.1	10711.4	3058.9	14509.5	3010.6	680.3	43957.8
Renewable	Biogas	2222.1	0.0	0.0	0.0	0.0	0.0	2222.1
	Microhydro	90.2	0.0	0.0	0.0	0.0	0.0	90.2
	Solar	3.1	0.0	0.0	0.0	0.0	0.0	3.1
Renewable Total		2315.4	0.0	0.0	0.0	0.0	0.0	2315.4
Grand Total		345384.3	12791.4	4673.8	14509.5	3010.6	680.3	381049.9

Energy Consumption in 2005/06
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	12502.2	1504.4	0.0	0.0	0.0	0.0	14006.6
	Animal dung	21626.2	0.0	0.0	0.0	0.0	0.0	21626.2
	Fuelwood	289449.0	802.5	2209.0	0.0	0.0	0.0	292460.4
Traditional Total		323577.4	2306.9	2209.0	0.0	0.0	0.0	328093.2
Commercial	ATF	0.0	0.0	0.0	2327.0	0.0	0.0	2327.0
	Coal	39.3	10324.7	0.0	0.0	0.0	0.0	10364.0
	Electricity	2900.6	2828.0	433.1	20.3	163.8	624.1	6969.9
	Fueloil	0.0	1.2	0.0	0.0	0.0	0.0	1.2
	Gasoline	0.0	0.0	0.0	2712.3	0.0	0.0	2712.3
	HSDiesel	0.0	186.7	0.0	8255.3	2721.9	0.0	11163.9
	Kerosene	6831.4	350.9	1035.6	0.0	0.0	0.0	8217.9
	LDiesel	0.0	0.2	0.0	8.3	2.9	0.0	11.4
	LPG	2183.6	0.0	1658.8	146.3	0.0	0.0	3988.7
	Other Petroleum	0.0	841.2	0.0	0.0	0.0	0.0	841.2
Commercial Total		11954.9	14532.9	3127.4	13469.5	2888.5	624.1	46597.3
Renewable	Biogas	2027.2	0.0	0.0	0.0	0.0	0.0	2027.2
	Microhydro	65.1	0.0	0.0	0.0	0.0	0.0	65.1
	Solar	2.9	0.0	0.0	0.0	0.0	0.0	2.9
Renewable Total		2095.2	0.0	0.0	0.0	0.0	0.0	2095.2
Grand Total		337627.5	16839.8	5336.4	13469.5	2888.5	624.1	376785.8

Energy Consumption in 2004/05
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	12478.3	1472.7	0.0	0.0	0.0	12.6	13963.5
	Animal dung	21181.4	0.0	0.0	0.0	0.0	0.0	21181.4
	Fuelwood	284138.4	772.7	2048.9	0.0	0.0	0.0	286960.0
Traditional Total		317798.0	2245.4	2048.9	0.0	0.0	12.6	322104.9
Commercial	ATF	0.0	0.0	0.0	2417.1	0.0	0.0	2417.1
	Coal	25.1	6434.3	0.0	0.0	0.0	0.0	6459.3
	Electricity	2729.4	2750.4	393.5	20.9	179.9	599.1	6673.2
	Fueloil	0.0	-27.7	0.0	0.0	0.0	0.0	-27.7
	Gasoline	0.0	0.0	0.0	2533.6	0.0	0.0	2533.6
	HSDiesel	0.0	199.2	0.0	8807.4	2903.9	0.0	11910.6
	Kerosene	7053.3	413.1	1192.2	0.0	0.0	0.0	8658.6
	LDiesel	0.0	0.1	0.0	2.5	0.9	0.0	3.4
	LPG	2007.5	0.0	1700.4	112.7	0.0	0.0	3820.7
	Other Petroleum	0.0	746.7	0.0	0.0	0.0	0.0	746.7
Commercial Total		11815.3	10515.9	3286.2	13894.2	3084.7	599.1	43195.4
Renewable	Biogas	1847.5	0.0	0.0	0.0	0.0	0.0	1847.5
	Microhydro	56.9	0.0	0.0	0.0	0.0	0.0	56.9
	Solar	2.7	0.0	0.0	0.0	0.0	0.0	2.7
Renewable Total		1907.2	0.0	0.0	0.0	0.0	0.0	1907.2
Grand Total		331520.5	12761.3	5335.0	13894.2	3084.7	611.6	367207.4

Energy Consumption in 2003/04
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	12220.9	1414.0	0.0	0.0	0.0	0.0	13634.9
	Animal dung	20745.7	0.0	0.0	0.0	0.0	0.0	20745.7
	Fuelwood	278220.0	742.9	1925.5	0.0	0.0	0.0	280888.3
Traditional Total		311186.6	2156.9	1925.5	0.0	0.0	0.0	315269.0
Commercial	ATF	0.0	0.0	0.0	2316.4	0.0	0.0	2316.4
	Coal	28.9	7263.4	0.0	0.0	0.0	0.0	7292.4
	Electricity	2434.9	2483.3	389.2	19.7	114.0	533.3	5974.5
	Fueloil	0.0	421.4	0.0	0.0	0.0	0.0	421.4
	Gasoline	0.0	0.0	0.0	2276.1	0.0	0.0	2276.1
	HSDiesel	0.0	190.1	0.0	8406.8	2771.8	0.0	11368.7
	Kerosene	9181.0	537.7	1551.9	0.0	0.0	0.0	11270.6
	LDiesel	0.0	0.4	0.0	16.9	5.8	0.0	23.1
	LPG	1711.3	0.0	1449.5	96.1	0.0	0.0	3256.8
	Other Petroleum	0.0	662.7	0.0	0.0	0.0	0.0	662.7
Commercial Total		13356.1	11559.0	3390.6	13132.0	2891.7	533.3	44862.7
Renewable	Biogas	1650.3	0.0	0.0	0.0	0.0	0.0	1650.3
	Microhydro	52.8	0.0	0.0	0.0	0.0	0.0	52.8
	Solar	2.2	0.0	0.0	0.0	0.0	0.0	2.2
Renewable Total		1705.3	0.0	0.0	0.0	0.0	0.0	1705.3
Grand Total		326248.0	13715.9	5316.1	13132.0	2891.7	533.3	361837.0

Energy Consumption in 2002/03
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	11969.6	1357.0	0.0	0.0	0.0	0.0	13326.6
	Animal dung	20319.0	0.0	0.0	0.0	0.0	0.0	20319.0
	Fuelwood	272323.0	712.5	1924.7	0.0	0.0	0.0	274960.2
Traditional Total		304611.6	2069.5	1924.7	0.0	0.0	0.0	308605.8
Commercial	ATF	0.0	0.0	0.0	1911.2	0.0	0.0	1911.2
	Coal	23.2	5698.2	0.0	0.0	0.0	0.0	5721.3
	Electricity	2221.6	2266.2	333.9	19.9	107.9	484.0	5433.5
	Fueloil	0.0	553.6	0.0	0.0	0.0	0.0	553.6
	Gasoline	0.0	0.0	0.0	2259.1	0.0	0.0	2259.1
	HSDiesel	0.0	190.3	0.0	8413.6	2774.1	0.0	11378.0
	Kerosene	10297.4	603.0	1740.6	0.0	0.0	0.0	12641.0
	LDiesel	0.0	0.4	0.0	17.5	6.0	0.0	23.9
	LPG	1450.9	0.0	1228.9	81.5	0.0	0.0	2761.3
	Other Petroleum	0.0	588.3	0.0	0.0	0.0	0.0	588.3
Commercial Total		13993.1	9900.0	3303.4	12702.8	2888.0	484.0	43271.3
Renewable	Biogas	1526.5	0.0	0.0	0.0	0.0	0.0	1526.5
	Microhydro	47.2	0.0	0.0	0.0	0.0	0.0	47.2
	Solar	1.7	0.0	0.0	0.0	0.0	0.0	1.7
Renewable Total		1575.5	0.0	0.0	0.0	0.0	0.0	1575.5
Grand Total		320180.1	11969.5	5228.1	12702.8	2888.0	484.0	353452.5

Energy Consumption in 2001/02
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	11723.4	1302.3	0.0	0.0	0.0	0.0	13025.7
	Animal dung	19901.1	0.0	0.0	0.0	0.0	0.0	19901.1
	Fuelwood	266724.4	683.8	1749.6	0.0	0.0	0.0	269157.7
Traditional Total		298348.9	1986.1	1749.6	0.0	0.0	0.0	302084.6
Commercial	ATF	0.0	0.0	0.0	1716.3	0.0	0.0	1716.3
	Coal	26.8	6454.3	0.0	0.0	0.0	0.0	6481.0
	Electricity	2008.6	2151.6	325.5	20.3	105.4	454.4	5065.8
	Fueloil	0.0	577.8	0.0	0.0	0.0	0.0	577.8
	Gasoline	0.0	0.0	0.0	2118.9	0.0	0.0	2118.9
	HSDiesel	0.0	181.6	0.0	8028.2	2647.0	0.0	10856.8
	Kerosene	11537.4	662.0	1818.4	0.0	0.0	0.0	14017.8
	LDiesel	0.0	1.4	0.0	69.2	23.8	0.0	94.4
	LPG	1301.4	0.0	1027.8	71.6	0.0	0.0	2400.8
	Other Petroleum	0.0	522.2	0.0	0.0	0.0	0.0	522.2
Commercial Total		14874.1	10550.9	3171.7	12024.6	2776.2	454.4	43851.9
Renewable	Biogas	1350.1	0.0	0.0	0.0	0.0	0.0	1350.1
	Microhydro	41.7	0.0	0.0	0.0	0.0	0.0	41.7
	Solar	0.9	0.0	0.0	0.0	0.0	0.0	0.9
Renewable Total		1392.8	0.0	0.0	0.0	0.0	0.0	1392.8
Grand Total		314615.8	12537.0	4921.3	12024.6	2776.2	454.4	347329.3

Energy Consumption in 2000/01
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	11482.3	1249.8	0.0	0.0	0.0	0.0	12732.1
	Animal dung	19491.8	0.0	0.0	0.0	0.0	0.0	19491.8
	Fuelwood	256416.3	644.1	1575.3	0.0	0.0	0.0	258635.6
Traditional Total		287390.3	1893.9	1575.3	0.0	0.0	0.0	290859.4
Commercial	ATF	0.0	0.0	0.0	2283.4	0.0	0.0	2283.4
	Coal	31.4	7415.0	0.0	0.0	0.0	0.0	7446.3
	Electricity	1866.1	1874.3	339.0	21.2	103.0	408.5	4612.1
	Fueloil	0.0	588.1	0.0	0.0	0.0	0.0	588.1
	Gasoline	0.0	0.0	0.0	1984.1	0.0	0.0	1984.1
	HSDiesel	0.0	206.8	0.0	9145.3	3015.3	0.0	12367.5
	Kerosene	9534.7	536.1	1401.2	0.0	0.0	0.0	11472.0
	LDiesel	0.0	2.0	0.0	98.0	33.7	0.0	133.7
	LPG	1102.9	0.0	812.2	59.5	0.0	0.0	1974.6
	Other Petroleum	0.0	482.1	0.0	0.0	0.0	0.0	482.1
Commercial Total		12535.1	11104.4	2552.4	13591.5	3152.0	408.5	43343.9
Renewable	Biogas	1179.2	0.0	0.0	0.0	0.0	0.0	1179.2
	Microhydro	38.1	0.0	0.0	0.0	0.0	0.0	38.1
	Solar	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Renewable Total		1217.5	0.0	0.0	0.0	0.0	0.0	1217.5
Grand Total		301142.9	12998.3	4127.6	13591.5	3152.0	408.5	335420.9

Energy Consumption in 1999/00
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	11246.1	1199.5	0.0	0.0	0.0	0.0	12445.5
	Animal dung	19090.9	0.0	0.0	0.0	0.0	0.0	19090.9
	Fuelwood	251142.3	618.1	1438.6	0.0	0.0	0.0	253199.0
Traditional Total		281479.2	1817.6	1438.6	0.0	0.0	0.0	284735.4
Commercial	ATF	0.0	0.0	0.0	2056.2	0.0	0.0	2056.2
	Coal	45.2	10458.7	0.0	0.0	0.0	0.0	10503.9
	Electricity	1681.4	1830.1	294.6	9.6	56.7	355.1	4227.4
	Fueloil	0.0	428.1	0.0	0.0	0.0	0.0	428.1
	Gasoline	0.0	0.0	0.0	1861.5	0.0	0.0	1861.5
	HSDiesel	0.0	197.0	0.0	8710.8	2872.1	0.0	11779.9
	Kerosene	10071.5	554.9	1380.0	0.0	0.0	0.0	12006.4
	LDiesel	0.0	2.4	0.0	114.5	39.3	0.0	156.2
	LPG	867.0	0.0	595.3	45.8	0.0	0.0	1508.1
	Other Petroleum	0.0	427.9	0.0	0.0	0.0	0.0	427.9
Commercial Total		12665.0	13899.1	2269.9	12798.5	2968.1	355.1	44955.6
Renewable	Biogas	981.4	0.0	0.0	0.0	0.0	0.0	981.4
	Microhydro	33.6	0.0	0.0	0.0	0.0	0.0	33.6
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Total		1015.0	0.0	0.0	0.0	0.0	0.0	1015.0
Grand Total		295159.3	15716.7	3708.5	12798.5	2968.1	355.1	330706.0

Energy Consumption in 1998/99
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	11014.8	1151.1	0.0	0.0	0.0	0.0	12165.9
	Animal dung	18698.2	0.0	0.0	0.0	0.0	0.0	18698.2
	Fuelwood	245976.8	593.2	1313.8	0.0	0.0	0.0	247883.8
Traditional Total		275689.7	1744.3	1313.8	0.0	0.0	0.0	278747.8
Commercial	ATF	0.0	0.0	0.0	2009.2	0.0	0.0	2009.2
	Coal	12.7	2880.6	0.0	0.0	0.0	0.0	2893.3
	Electricity	1478.0	1587.6	278.4	9.4	82.2	342.3	3777.9
	Fueloil	0.0	189.4	0.0	0.0	0.0	0.0	189.4
	Gasoline	0.0	0.0	0.0	1674.3	0.0	0.0	1674.3
	HSDiesel	0.0	251.1	0.0	11103.1	623.3	0.0	11977.5
	Kerosene	9051.1	488.6	1156.4	0.0	0.0	0.0	10696.0
	LDiesel	0.0	0.3	0.0	15.7	5.4	0.0	21.4
	LPG	728.1	0.0	466.2	37.7	0.0	0.0	1231.9
	Other Petroleum	0.0	379.8	0.0	0.0	0.0	0.0	379.8
Commercial Total		11269.9	5777.4	1901.0	14849.3	710.9	342.3	34850.8
Renewable	Biogas	826.0	0.0	0.0	0.0	0.0	0.0	826.0
	Microhydro	29.7	0.0	0.0	0.0	0.0	0.0	29.7
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Total		855.7	0.0	0.0	0.0	0.0	0.0	855.7
Grand Total		287815.3	7521.7	3214.8	14849.3	710.9	342.3	314454.3

Energy Consumption in 1997/98
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	10788.2	1104.7	0.0	0.0	0.0	0.0	11892.9
	Animal dung	18313.6	0.0	0.0	0.0	0.0	0.0	18313.6
	Fuelwood	240917.5	569.3	1199.8	0.0	0.0	0.0	242686.6
Traditional Total		270019.3	1674.0	1199.8	0.0	0.0	0.0	272893.1
Commercial	ATF	0.0	0.0	0.0	1859.6	0.0	0.0	1859.6
	Coal	11.2	2490.8	0.0	76.9	0.0	0.0	2578.9
	Electricity	1363.6	1489.5	257.3	6.0	104.6	321.6	3542.5
	Fueloil	0.0	53.9	0.0	0.0	0.0	0.0	53.9
	Gasoline	0.0	0.0	0.0	1572.0	0.0	0.0	1572.0
	HSDiesel	0.0	413.3	0.0	10003.9	984.7	0.0	11401.9
	Kerosene	8725.3	461.5	1039.4	0.0	0.0	0.0	10226.3
	LDiesel	0.0	0.6	0.0	27.7	9.5	0.0	37.9
	LPG	708.0	0.0	422.6	0.0	0.0	0.0	1130.6
	Other Petroleum	0.0	337.1	0.0	0.0	0.0	0.0	337.1
Commercial Total		10808.1	5246.6	1719.4	13546.1	1098.8	321.6	32740.5
Renewable	Biogas	678.1	0.0	0.0	0.0	0.0	0.0	678.1
	Microhydro	27.3	0.0	0.0	0.0	0.0	0.0	27.3
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Total		705.4	0.0	0.0	0.0	0.0	0.0	705.4
Grand Total		281532.8	6920.6	2919.2	13546.1	1098.8	321.6	306339.0

Energy Consumption in 1996/97
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	10566.3	1060.2	18.6	0.0	0.0	0.0	11645.1
	Animal dung	17936.9	0.0	0.0	0.0	0.0	0.0	17936.9
	Fuelwood	235962.3	546.3	1046.8	0.0	0.0	0.0	237555.5
Traditional Total		264465.5	1606.5	1065.4	0.0	0.0	0.0	267137.5
Commercial	ATF	0.0	0.0	0.0	1731.2	0.0	0.0	1731.2
	Coal	10.1	2195.2	263.8	70.6	0.0	0.0	2539.7
	Electricity	1278.7	1356.3	243.4	5.3	100.7	293.2	3277.6
	Fueloil	0.0	275.8	43.9	0.0	0.0	0.0	319.7
	Gasoline	0.0	15.4	0.0	1481.9	0.0	0.0	1497.3
	HSDiesel	0.0	340.8	0.0	8595.6	846.1	0.0	9782.5
	Kerosene	7100.5	368.0	1372.0	0.0	0.0	0.0	8840.6
	LDiesel	0.0	1.2	0.0	56.9	19.5	0.0	77.6
	LPG	925.2	0.0	149.5	0.0	0.0	0.0	1074.6
	Other Petroleum	0.0	258.1	41.1	0.0	0.0	0.0	299.2
Commercial Total		9314.4	4810.8	2113.7	11941.6	966.3	293.2	29440.2
Renewable	Biogas	536.3	0.0	0.0	0.0	0.0	0.0	536.3
	Microhydro	24.7	0.0	0.0	0.0	0.0	0.0	24.7
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Total		561.0	0.0	0.0	0.0	0.0	0.0	561.0
Grand Total		274341.0	6417.3	3179.2	11941.6	966.3	293.2	297138.7

Energy Consumption in 1995/96
Unit in 000 GJ

Category	Fueltype	Sector						
		Residential	Industrial	Commercial	Transport	Agricultural	Other	Grand Total
Traditional	Agr residue	10349.0	205.0	17.0	0.0	0.0	0.0	10571.0
	Animal dung	17568.0	0.0	0.0	0.0	0.0	0.0	17568.0
	Fuelwood	231109.0	3430.0	956.0	0.0	0.0	0.0	235495.0
Traditional Total		259026.0	3635.0	973.0	0.0	0.0	0.0	263634.0
Commercial	ATF	0.0	0.0	0.0	1469.2	0.0	0.0	1469.2
	Coal	15.0	2600.8	366.1	103.0	0.0	0.0	3085.0
	Electricity	1183.4	1291.2	226.5	5.2	90.3	262.2	3058.9
	Fueloil	0.0	308.2	32.6	0.0	0.0	0.0	340.9
	Gasoline	0.0	14.2	0.0	1365.3	0.0	0.0	1379.6
	HSDiesel	0.0	3294.7	0.0	5650.6	556.2	0.0	9501.5
	Kerosene	6087.0	384.3	1096.7	0.0	0.0	0.0	7568.0
	LDiesel	0.0	2.7	0.0	127.7	43.9	0.0	174.2
	LPG	796.0	0.0	119.9	0.0	0.0	0.0	915.9
	Other Petroleum	0.0	240.2	25.4	0.0	0.0	0.0	265.6
Commercial Total		8081.4	8136.3	1867.3	8720.9	690.4	262.2	27758.5
Renewable	Biogas	411.9	0.0	0.0	0.0	0.0	0.0	411.9
	Microhydro	23.0	0.0	0.0	0.0	0.0	0.0	23.0
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Total		434.8	0.0	0.0	0.0	0.0	0.0	434.8
Grand Total		267542.3	11771.3	2840.3	8720.9	690.4	262.2	291827.4