Chapter 3

REVIEW OF LITERATURE

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Introduction

The energy scenario in India has a definite long history, which emerged for the first time in 1959 when the Government of India had set up the National Council of Applied Economic Research (NCAER), in New Delhi, to conduct energy survey in the country for establishing a scientific back up of energy research and development. Several studies have been conducted from time-to-time on energy consumption patterns of different areas at national level or frequently at regional level, forming milestones of research in this discipline. Since these works offer background information about ways of earlier researches on this field, a brief review of such literatures is necessary to find and select areas and techniques for present and future researches.

National and Regional Level Studies (TamilNadu)

According to NCAER (1959), energy demand for household sector has been increasing every year mainly because of rapidly growing population and rising income, both of which offer a social pressure on people to improve their standard of living. Though it was, at that time, estimated that non-commercial sources could provide roughly 40.0 per cent of energy required for households, the actual energy consumption pattern fluctuated depending on seasonal availability of energy sources, and it varied from state to state and from district to district because of some static features predominant in the areas.

The NCAER-, based on primary data collected from rural and urban households in 1978-79, reported that in 1985, in India, household’s consumption
of commercial energy increased tenfold during 1953-1979, whereas use of non-commercial energy decreased from 71.6 per cent to 34.0 per cent, and that over 83.0 per cent of rural population relied on the non-commercial resources.

The Energy Survey Committee of India (1965) reported that in 1960s the country consumed about 120 million tonnes of firewood, 30 million tonnes of crop residues and 50 million tonnes of dung cake to meet its cooking energy needs, of which a major portion was used in rural parts.

Grayson et al. (1972), analysed the relationship between energy consumption and economic growth of developing countries like India, Pakistan, Bangladesh and Sri Lanka, and found out that Gross National Product directly correlates with the level of economic activity. However, least importance was given to energy consumption in household sector.

During 1970-'71, India had consumed about 126 million tonnes of firewood and 68 million tonnes of dung cake, of which over 83.0 per cent and 92.0 per cent respectively were consumed in rural areas, that is, rural parts of India consume more of non-commercial energy than urban areas (Henderson, 1972).

Anon (1974), in a report of Fuel Policy Committee in 1974, pointed out the fact that nearly half of the total energy consumed in India comes from non-conventional resources including solar, wind, hydro-electric and biomass energy.

Mallik (1977) analysed the household energy consumption pattern with respect to cooking and lighting - the two major end uses of firewood in Orissa, and estimated that the average firewood consumption in the state was 394 kg/family/month.
Von Oppen (1979) concluded that in Hyderabad a major portion of energy in 1978 was consumed by household sector and firewood was the predominant fuel being used by over 70.0 per cent of the household in that state. Diesel and electricity, which were the most wanted energy source for productive purposes, were used in small quantities in the household sector for cooking.

ASTRA-the Centre for the Application of Science and Technology to Rural Areas, at the Indian Institute of Science, Bangalore (India) – in 1981 conducted a study on energy consumption pattern of Ungra village of Karnataka to determine developmental objectives for energy strategies in Karnataka state.

The United Nations Conference on New and Renewable Sources of Energy (1981), in its second session of Technical Panel on Firewood and Charcoal', reported that fuel wood and organic fuels are the major sources of energy for the survival of the world’s poor people. It also described the problems and constraints affecting potential use of firewood and charcoal in India (TPFC, 1981).

A study on the working conditions of women in South Bihar conducted by Ninan (1981) pointed out that every day about 300 women went to the forest, cut timber and wood, and carried them to markets in towns which are situated 12 Km away from the forests, by bicycles and by train. This work also recommended village headmen to take attempts to prevent axing of forests by women. A similar situation was noticed in Orissa (Fernandes and Menon, 1987), Bihar (Agarwal, 1987) and Rajasthan (NWDB, 1988).

ASTRA (1982) conducted a field study on the rural energy consumption pattern in a few villages around Bangalore in 1981, and concluded that gathering
firewood, fetching water, cooking and other domestic tasks use a substantial share of women's and children's energy output around 700 and 300 calories respectively per day. If fuel and water were available near the homes, if cattle fodder could be had without much effort, and if efficiency of chulhas were improved, the greater part of energy could be used for more of productive purposes that are economic and eco-friendly.

Parthiban (1982) concluded that the farm-produced resources and non-purchased energy are not abundant in Madurai city, and hence the city has faced an acute fuel problem, especially among middle class people. The low income group was depending on the cheapest form of fuels that could be collected from near by areas, so there was no problem of fuel price, but high income group, as they could afford LPG and kerosene, did not feel it was a costly commodity. Firewood use in the city increased to 7.5 per cent between 1979 and 1982.

Hill (1982) took attempts to detect a plant species which can tolerate drought and grow in waste lands, to plant them in agroforests for getting enough firewood to meet cooking energy needs. *Prosopis, Zizyphus, Casuarina* and *Eucalyptus* were found to be suitable for agro-forest systems to overcome fuel wood crisis in India.

Warner (1982) estimated that wood productivity of Indian forests was 0.4 m$^3$ (4 metric tonnes) of wood per hectare / year by using remote sensing method. But, later surveys performed by Forest Survey of India (FSI, 1988) confirmed that productivity of forests in India is 0.7 m$^3$ of wood/ha/year. According to a report of Planning Commission, Government of India (GOI, 1982), the firewood demand at that time was approximately 133 million tonnes, whereas the estimated availability was only 94 million tonnes, leaving a shortage of 39 million
tonnes / year. This was the main reason for ecological imbalance, which forced households to overuse wood resources leading to forest destruction.

Amulyakumar et al. (1983) conducted a case study of firewood consumption of Bangalore with reference to a sample of 1,000 households in the north-western villages, and concluded that only 16.1 per cent of the population relied on wood fuel for cooking and water heating, and 18.4 per cent of population used it for water heating alone while most of that population (over 65.5 per cent) neither used it for cooking nor for water heating.

Srilatha (1983), while searching for impacts of cooking fuels on women’s health by selecting four villages of Kaira District of Gujarat, concluded that conventional biomass fuels emit more benzo-a-pyrene, carbon monoxide and polycyclic compounds than firewood. The emission of these substances increased to a great extent while using crude stoves in poorly ventilated rural houses, which was the main cause for respiratory diseases in women and girls.

Reddy and Reddy (1983) conducted a detailed study of firewood consumption of urban parts of India with special reference to Bangalore city, and showed that the urban parts of India as a whole consumed about 594-609 tonnes of firewood per year.

Gellar (1983) analysed fuel efficiency and performance of traditional and innovative stoves by burning firewood, and found out that improved smokeless chulhas were more efficient in energy saving with reduced level of carbon dioxide emission.

De Montalembert et al. (1983) estimated the wood energy requirements for Himalayan mountainous communities to be 1.8-2.1 m³ / head / year, and they,
by their case study, observed that woody species such as *Quercus* sps., *Pinus roxburghii*, Sargent, etc. and thorny shrubs like *Euphorbia roylello*na, Boissier and *Lantana camera* were collected from woodlands and protected forests as fuel. As noticed in the Himalayan mountains, in the Central Himalayas too fuel wood contributed 73.0 per cent energy required for cooking and water heating for people living on foothills, but people living on high hill regions completely relied on firewood not only for cooking and water heating but also for keeping their houses warm (Pandey and Singh, 1984; Melkania and Uma Melkania, 1988; and Hema Patel, 1991).

The higher rate of urbanization prevalent in developing countries due to migration of poorer sections of society from rural areas has been the main reason for increase in demand for firewood in urban centres (Schloz, 1983; and Whyte, 1985).

Mathur et al. (1984) made cost-benefit analysis of *Eucalyptus* on farm lands, especially in bunds of farm lands, to enhance firewood production and recorded that one hectare of land yielded 15 tonnes of woods per year, that could fetch Rs.37,500 in five years against a total investment of Rs.10,000. But, later on, it was proved that *Eucalyptus*, if raised on bunds, causes crop loss to some extent (Suresh et al., 1987; Shah, 1988; Ahmad, 1989; Chaturvedi, 1989; Malik and Sharma, 1988; and Shukla, 1991) so that it should preferably be planted in areas not suitable for other crops (Saxena, 1991).

Alam et al., (1985), as a result of field survey on firewood consumption in Hyderabad city conducted in 1981-'82, concluded that in Andhra Pradesh per capita firewood consumption of rural areas was 180 kg / capita / year which was lower than that of urban areas (115 kg / capita / year) because of the use of
efficient stoves and alternative fuels in the urban areas. Their research findings correlated with what was observed by NCAER (1985) at the national level. However, it has to be noted that during the study, households were selected from villages with special reference to landholding classes, so the actual reliability was poor. Similar observations were made by ESMAP (1991), Bowder et al., (1987) and IWST / ICFRE (2001), which also confirmed that consumption of firewood and charcoal has been increasing every year at a constant rate.

Based on primary data collected from field survey of rural parts in 1984, it was concluded that rural areas of TamilNadu had consumed about 271 kg of firewood per head per annum (Anon, 1985). Such state level studies were conducted in Jammu and Kashmir (DES, 1987), Haryana (NCAER, 1988), Gujarat (FSI, 1985), Kerala (KFTRI, 1989), Orissa (ORG, 1989), West Bengal (FSI, 1987), Karnataka (IIMB, 1993), Himachal Pradesh (Singh et al., 1994), and Andhra Pradesh (ICFRE, 2001), but their results were very poor in reliability, since those were based on only 1,000 or even lesser number of samples selected from a small area.

A report of NCAER (1985), based on primary data of firewood consumption collected between 1978-'79 and 1985, showed that, in agriculturally prospectus states such as Punjab, Haryana, U.P., and Bihar consumed more of dung cake and agro-residues, but the other states of India had declined from 16.5 million tonnes in 1978 to 9.5 million tonnes in 1985, because of the rise in consumption of LPG and kerosene in urban areas.

The collection of firewood from common lands and carrying them on their head to the nearest market is an important profession of 170 households in Ranchi (Agarwal and Narain, 1985) and of several households in Rajasthan
(NWDB, 1988) and Madhya Pradesh (Agarwal, 1987). It is believed that at least 3-4 million people in rural India are involved in this profession and firewood collection and selling seems to be India’s biggest source of employment in the energy sector (Agarwal, 1987).

The Biomass Research Centre of National Botanical Garden, Lucknow, reviewed that 11 plant species growing in India, viz., *Acacia auriculiformis*, *Acacia nilotica*, *Albizia Lebbeck*, *Azadirachta indica*, *Dalbergia sissoo*, *Eucalyptus hybrids*, *Pithecellobium dulce*, *Pongamia pinnata*, *Prosopis juliflora* and *Terminalia arjuna* have good adaptability to alkaline soils and produce wood in larger amounts (Chaturvedi et al., 1985). Later on, Dayal (1986) recommended certain parameters such as high adaptability, case of establishment, suitability for problematic regions, nitrogen fixing ability and high rate of wood production to select plants that have to be planted in an area to get enough firewood.

Singh and Berry (1985) examined the consumption of non-conventional energy sources by the people of the valley in Dehradun forest, and estimated the energy needed for cooking in the valley to be 1.56 giga cal per capita.

Bowonder et al., (1986), by their studies on energy use pattern in ten villages from states of Karnataka, Andhra Pradesh and Maharashtra, showed that increased irrigation and planned use of agro-residues could reduce the firewood consumption, since energy use was closely related to socio-economic and agroclimatic factors like income, size of land hold, cattle population, and availability of crop residues.

Whilst studying firewood consumption in households of Madurai district (TamilNadu), Vijayan (1986) concluded that women were the decision makers
who determined the type of fuel to be used for cooking, and that 58.3 per cent of households used firewood, 20.0 per cent of households used kerosene and the rest used dung cake as cooking fuels.

Maithani et al. (1986) studied fuel wood consumption in Karaundhi village of Sahranpur district (North India) in relation to profession, family income, size of land holds, family size and number of cattle owned.

In the villages of Garhwal Himalaya, firewood consumption in rural area (Dumlor) was 0.83 tonnes / capita / year and that in rural area (Raath) was 0.53 tonnes / capita / year and further, wood was mainly collected from natural forests (Batwal, 1987).

Reddy and Reddy (1987) estimated that in Ungra Village (South India) about 32.6 percent of fuel wood is collected from nearby areas and the actual firewood consumption is 441.0 kg / capita / year.

Knool (1987) analysed firewood consumption in three villages of North India with special reference to economic groups, and concluded that poor people used 4.2 kg / head / day, middle class people consumed 3.8 kg / head / day and rich people used 3.3 kg wood / head / day.

Hemlata Rao (1987) assessed the energy consumption pattern of three villages of Mysore, Karnataka, between March 1986 and February 1987, and came to a similar conclusion drawn by Bowonder et al., in 1986.

For Charma block of Garhwal district (UP), firewood was the main source of fuel for households living at higher altitudes and the wood consumption
decreases with lowering altitudes because of a large share of cattle dung and agro-residues in energy supply (Sharma et al., 1987).

Girija Sharma (1987) studied the energy use of rural Gujarat in relation to domestic sector, agriculture, artisans and common industrial units, and showed that per capita use of wood; twigs and crop residues vary from 31 kg / month for landless poor to 35 kg / month for large land owners.

Srivastava (1987) reported 106 species of trees and shrubs, which could grow well in alkaline soils around Lucknow to increase firewood production. In the next year, he noted some weeds – Sida sps., Triumfetta sps., Cassia tora, Cassia occidentalis, Crotalaria medicagenia, Croton sparciflorous, Xanthium strumarium, Corchorus sps., Urena aspera, Anisomelos ovata, Hyptis suaveolens, Abutilon sps., Zizyphus sps., Carissa sps., Lantana camera and Nyctanthes sps., which were used as agro-residues for fuel (Srivastava, 1988).

The Forest Survey of India (1987) estimated that India consumes about 235 million cubic meters of wood per year for fuel and other purposes but sustainable wood production of Indian forests is only 40 million cubic meters / year, leaving a gap of 195 million cubic meters shortage every year.

Gurumurthi et al., (1987) had shown that, it is possible to solve the fuel wood crisis within 5-10 years, if rapidly growing trees are planted in 20 million more hectares of wastelands in India by adopting community and joint forest management approach.

A case study of firewood consumption in rural areas of Almora district showed that per capita firewood consumption is 0.77-0.72 tonnes / year in villages with developed blocks and head quarters, 0.55-0.78 tonnes / year in
villages with predominant scheduled castes, 0.64-0.86 tonnes / year in villages
without proper electricity and roads, 0.89-0.91 tonnes / year in villages with
electricity but no road, and 0.99-1.00 tonnes / year in villages with electricity and
roads (Shukla, 1987).

Bowonder et al., (1988) traced the energy consumption pattern in eight
villages in a semi-agroclimatic regions of Hyderabad, and concluded that the
higher the per capita income, the higher was the firewood consumption for
cooking and the firewood use per capita was 343 kg / head / year. It also
estimated that the annual firewood consumption in Hyderabad was 3,96,360
tonnes instead of 1,77,700 tonnes as stated by the previous studies in 1985. The
monthly fuel wood consumption of households is 0.7455 tonnes for Rs.0-700 /
month income group, 0.2627 tonnes for Rs.701-1,400 / month income group,
0.862 tonnes for Rs.1,401-2,500 / month income group, and 0.1787 tonnes for
those earning more than Rs.2,500 per month.

Wood fuel which is the fourth largest source of cooking energy-after
petroleum coal and LPG in India-was consumed at a rate of 182 million m$^3$/year
but its actual production rate was 12.5 million m$^3$/year, leaving the deficit of 170
million m$^3$/year (Gurumurthi et al., 1988) In the forecast study for 2000, it was
estimated that firewood requirement in 2000 could be 230 million m$^3$, of which
over 70 million m$^3$ wood was to be used for industries (Sharma et al., 1988).

Harridur Ramcharran (1988) concluded in his study on the residential
demand for energy in Jamaica that demand for LPG and kerosene is elastic due
to income elasticity, and that people substitute indigenous charcoal for LPG and
kerosene at household level, as a measure for adjusting their cost of living within
their income.
Tokey and Bimlendra Kumari (1988) had listed about 120 firewood yielding species best suited for semi-arid regions for getting firewood to meet the future demand, but, of which Mahot et al., (1988) recommended only 41 plant species for energy plantation programmes in India. Several other works discussed potential firewood species for Rajasthan (Sikha and Kumar, 1988), Himalaya (Melkania et al., 1988), Andaman and Nicobar (Vasudeva Rao et al., 1988), Visakapatnam in AP (Vimal et al., 1988), Pakistan (Hussain, 1989) and TamilNadu (TNRFP, 1993).

Dasgupta (1988) pointed out that gathering firewood is the important economic activity of poor women and forest dwellers whose livelihood are precariously based. It is the main cause for stress, which leads to depletion of forest in India.

Firewood demand for commercial and industrial sectors is low and estimated to be only 20.0 per cent of the total consumption, but that for household sector is as high as 80.0 per cent (World Bank, 1988). While it seems to be true, households of rural areas near forests are the main cause of deforestation since they prevent natural regeneration in forests and damage existing vegetation therein (Blockhus et al., 1992).

Bowder et al., (1988) reported that in Hyderabad, soap factories had consumed 21,900 tonnes of fuel wood per year, alcohol distilleries had used 68,620 tonnes of wood fuel per year, and backing units consumed about 28,835 tonnes of wood fuel per annum. Similarly, Ashraff et al., (1988) showed that 2 kg of firewood is required for processing of every kilogram of tea ready for marketing.
Cooking with collected firewood and agro-residues is the cheapest option as long as the time spent on collection has no equivalent monetary value, whereas cooking with purchased firewood in traditional stoves is more expensive than LPG and kerosene which are considered too expensive to purchase (Leela, 1989).

In dry areas where there is low employment opportunities in the slack season, Prosopis alone can solve the fuel wood crisis and provide employment to many people who prune the branches and sell them to urban people (CIDA, 1987; and Saxena, 1989).

Hema Patel (1989) presented an interesting point that energy gathering of the poor does not cause deforestation as people collect only little twigs, branches, leaves and whatever they find in nearby areas. Further, it informs that cooking energy constitutes nearly half of India’s total energy consumption and is rising at a rate of six per cent per year due to rapid population explosion.

In Haryana, the market price for fuel wood in 1989 was Rs.250-300 / tonne, but the farmers got only Rs.120-105 / tonne, since they sold the firewood through commission agents (Athreya, 1989).

Chakrabarti (1989) concluded that in West Bengal, families earning less than Rs.250 / month consumed 0.8 m³ / capita / year, those earning Rs.501-1,000 / month consumed 0.04 m³ / capita / year, those earning Rs.1,001-1,500 / month consumed 0.03 m³ / capita / year, and those families earning Rs.1,501-2,000 / month consumed 0.03 m³ / capita / year; that is, firewood consumption in families decreases with rising family income. The same was true with the findings of Rajan Kumar Bose et al., (1990) in Uttar Pradesh.
In Agasteeswaram block of Kanyakumari district, the energy consumption pattern of households depends on the availability and price of energy sources and income of people, which are the three deciding factors that determine the social status of living, and on educational status and family size (Murugan, 1990).

Moorthy (1990) has discovered that, of the total energy consumed by household sector, 71.72 per cent is used for cooking, 17.84 per cent is used for water heating and remaining 3.0 per cent is used for lighting. He further concluded that cooking energy consumption is rather inelastic in low-income families but elastic in high income families which, for maintaining a social status, more often turn to LPG and kerosene. Increase in family income allowed people to use devices for modern fuels, which in turn reduce the fuel wood consumption, as observed by Bala et al (1990) and Jayant Sathya et al.,(1990).

A comparative analysis of rural energy consumption in three unelectrified villages of Eastern Uttar Pradesh showed that wood is the most widely used non-commercial fuel for households and its use increases gradually to a certain extent with increase of family income(Rajan Kumar Bose et al., 1990).

A survey conducted on fuel wood consumption in rural parts of Gujarat by Hema Patel (1990) showed that in the state nearly 78-99 per cent of wood is used for cooking, 1.1 per cent wood is used for industries as raw materials and 1.5 per cent wood is used for lighting. Per capita firewood consumption in that state is 310-420 kg/capita/year, and neem, sabul, khijado and crop residues have occupied a prominent place.
Dunkerley et al. (1990) while studying domestic energy consumption in Indian cities, have shown that fuel choice decisions vary directly with income, i.e. the higher the income level, the greater the tendency of households to use kerosene and LPG over wood fuel. They further, state that firewood seems to be inferior good, whose consumption declines about 7.0 per cent associated with a 10.0 per cent rise in the family income.

On the issue, whether fuel wood collection is leading to depletion of forest, Natarajan (1990) argues that, if any extraction of wood is above the sustainable level and if this trend continues, Indian forests would vanish. But the women who collect firewood from forests assert that felling of forest trees is due to outside contractors but not by women themselves who are collecting firewood from forests, since they collect dry branches and wood alone.

A study conducted in Karikal block of Pondicherry highlights households of coastal regions as consuming *Casuarina* stem which is available in surplus amount in sea-coasts, along with kerosene, and the households in interior parts use more of other firewood with little or no kerosene. Further, the study has revealed that household energy consumption varies with farm size and income group (Poyyamozhi, 1991; Ramakrishnan, 1992).

Sekar (1991) confirmed that cost effective innovations are not at all adopted by rural households but are being used by a large number of urban households to save cooking energy, and that a great homogeneity is seen in energy consumption in a particular income class.

Hema Patel (1991) realized that, in the upper Garhwal Himalayas (UP), women walk at least 10km on three days a week for an average of 7 hours
per day to bring about 25 kg of wood each head load for cooking and other
domestic purposes. Households in high hills consume 1,573 kg of wood per year
instead of 787 kg of wood being consumed by a household in a plain per year.
She further observed that in desert and hill stations where chances for
agriculture are minimum, people use 65.0 per cent and 67.0 per cent of energy
from firewood respectively, because of very little availability of crop residues.

About 800 X 103 tonnes of wood is harvested from *Hevea brasillensis*
grown in Thailand and used for drying and smoke for preservation of rubber
sheets in rubber industries (Prasertsan et al., 1991).

Maikuri (1991) studied domestic firewood consumption in four tribal
villages of Arunachal Pradesh and concluded that households in Nishi consumed
10.4 kg of wood/capita/day, households in Kachari consumed 3.1 kg/capita/day,
and households in Chackma consumed 4.9 kg/capita/day, and that firewood
source to them is mainly natural forests.

Dhanapal (1992) analysed firewood consumption of households in
Sittilingi, a tribal village of TamilNadu, and observed that per capita fuel wood
consumption was 590 kg/capita/year. The high capita of firewood consumption
was due to high altitude of that area and the cool climate, which needs frequent
heating up of indoor environment by wood full or charcoal.

Joshi et al. (1992) showed that in TamilNadu, wood and agro-residues are
the most preferred energy sources with 4.0-18.0 per cent fuel efficiency are used,
electricity is best preferred for lighting, and petroleum is preferred for
transports and diesel-powered pumps.
Patel and Singh (1992) estimated that the average annual firewood consumption in rural household of North Gujarat agroclimatic zone is 540 kg/year.

In Kambilampatti village of Dindigul, Tamil Nadu, household sector used 47.6 percent of energy from firewood, 40.2 percent of energy from crop residues, 10.2 percent energy from kerosene, 1.1 percent energy from electricity and 0.5 percent from dung cake (Ramaswamy et al,1993).

As in most developing countries, household sector of India is the largest energy consumer accounting for almost half of total energy consumed in an area (Varadarajan, 1993). This work also confirms that India’s urban population uses 22 million tonnes of firewood at a cost of Rs.400/tonne and another 7-8 millions tonnes of wood from trees having some timber value at a cost of Rs.300 crores. Firewood are carried to Delhi by rail and at Tughlakabad railway station 12,423 wagons of firewood each carrying 18 tonnes, are off loaded for selling. Thus, nearly 2,23,600 tonnes of firewood are sold to different sectors in Delhi.

Natarajan (1993) examined the correlations between energy use and standards of living and concluded that as standard of living rises, per capital energy use gradually increases to some extent.

In Mudumalai (TamilNadu) per capita firewood consumption is 340 kg/capita/year (Ganesan, 1993) whereas in Kadavakurichi reserve forest in foothills of Palani hills, the actual per capita fuel wood consumption is 720 kg/capita/year (Appasamy,1993).
RWEDB(1993) showed that in India, firewood is generally gathered by rural and urban poor but is purchased from markets by rural rich and middle class urban people.

Improved cooking stoves are superior to hearths in energy saving and reduces carbon dioxide emission for reducing health hazards to women. Health hazards are not uncommon in poor women who burn crop residues such as dried leaves and twigs in hearths (Sugumar, 1990). Mud chulhas are preferred by poor and middle class people in rural and urban areas, but iron stoves are used by people who are richer but unable to purchase kerosene or LPG for cooking (Sarin et al, 1983). The fuel efficiency of a hearth is 1.3-7.3 per cent of one mouthed mud chulha is 4.3-10.0 per cent of Indian ‘U’ chulha with grate is 15.8 per cent, of iron stove is 17.4 per cent, and of improved smokeless chulha is 12-19.5 per cent (Gill,1985). Barnes et al. (1994), has roughly calculated that India has been quickly disseminating improved chulhas to about 8 million households to reduce firewood consumption and indoor air pollution. Parikh and Vijayalaxmi(2000)in a survey of 5,028 households in rural part of TamilNadu, observed that respiratory diseases are 1.6 per cent higher in people using firewood and that over 43.0 per cent of people use firewood only for cooking.

Raj et al (1995) found that in Srivaikuntam taluk of Tuticorin district the average family size is 5.11 which consumes 118859.6 MJ/hh/year. Further, they concluded that agriculture labourers consume 30917.3 MJ/hh/year, agriculturists consume 32980.2 MJ/hh/year;, salaried employees consume 19860.8 MJ/hh/year and business people consume 35101.7 MJ/hh/year by burning firewood. But in Gujarat state, Khanna and Mahendra (1995)
estimated that the actual firewood consumption is 0.035 tonnes /capita/year; that is 555.1 MJ/hh/year.

Saksena et al (1995) concluded that in Garhwal Himalaya, per capita firewood consumption varies with seasons that are 0.33 kg/capita/day in monsoon 0.32 kg/capita/day in winter and 0.25 kg/capita in summer because of large variations in temperature. In general, winter climate needs more wood to warm indoor environment.

Indian forest have contributed 32.0 per cent of total firewood consumed by household sector and in semi arid areas natural regeneration of *Prosopis* on wasteland seems to be an ideal way for getting enough firewood to meet the cooking energy needs. (Ravindranath and Hall, 1995). But a report of Forest Survey of India reported that nearly 51.0 per cent of wood fuel for households is supplied by forest and remaining 49.0 per cent is provided by non-forest resources (FSI, 1995).

Misra et al (1996) showed that in Berhampur city 49.0 per cent of energy for domestic purpose is obtained from firewood and per capita firewood consumption is 65 kg/capita/year which are very low when compared to the other Indian cities. The annual per capita energy consumption is 22 MJ from leaf litter and 109 MJ from agro residues.

Dr. Muthuchelian and Vasudevan (1996) estimated that per capita firewood consumption in Madurai city is 3 kg/family/day but that in Checkanurani is 6 kg/family /day and that cost of fuel wood is Rs 2.60 /kg in Madurai and Rs 1.70 in Checkanurani. Each hotel in Madurai consumed 123 kg of wood per day but hotels in Checkanurani used only 48 kg wood/day since they
were very too small and provide food for a smaller number of consumers. Further, in Madurai, brick kilns used 1,714 kg / day/unit and dyeing factories used 45 kg wood/day/unit both of which were not found in Checkanurani village. Marriage halls in Madurai could use about 77 kg of wood per day whereas those in Checkanurani used only 64 kg wood per day. Besides these, this study confirms that in Checkanurani, each bakery consumes 20 kg wood/day and the cremation ground uses an average of 7kg of wood per day, instead of 1,000 kg/day required for a cremation ground in Madurai.

The dependence of people on size wood in rural areas is likely to be continued for a long time, though there is a downward trend in fuel wood consumption while there is some improvement in the poverty conditions (Saxena, 1997).

Agarwal (1998) argued that the impact of urban fuel wood demand is worse because it demands more logs which involves cutting of whole trees, but impact of rural fuel wood demand is comparatively harmless to existing forest vegetation.

A study conducted by Kohlin showed that women collect more firewood for cooking than men do, and that low income and landless households are more likely to be market suppliers of fuel wood than any other income groups. Further more, it was observed that rate of fuel wood collection declines with decrease in forest stock (Kohlin, 1988) and that households needed to spend more time in wood collection while small forest stocks were low (Heltberg et al., 2001). If such conditions prevail in an area, people tend to collect fuel wood from common lands and private resources.
Prasad et al., (1999) showed that in places where market value for fuel wood is low because of transition of many people to other fuels, wood produced from farm forestry is used by the farmers themselves as firewood or is burnt in an open place to make charcoal that can be sent to far away markets for sale. Yet other point mentioned in the paper is that for Indian villages 2/3 of fuel wood is supplied by forest resources and the remaining by common lands and private lands. But Kerala state is an exception, where about 80.0 per cent of fuel wood required for household is fulfilled by home-gardens and their plantations (Saxena, 1997).

Even difficulties such as higher scarcity of forest stocks and higher collection time in Rajasthan could not stop firewood collection and could not change the attitude of people to substitute other fuels for cooking (Heltberg et al., 2000).

Sunitha Patra (2001) analysed the energy consumption pattern in Berhampur town and she concluded that fuel wood is the most important energy source for households and that firewood consumption increases gradually with increase in family size and family income. Because of income elasticity, many families use firewood in combination with kerosene or dung cake to meet the cooking energy demand.

Theenathayalan (2001) presents an interesting information that in Madurai city, firewood was the most common energy source for cooking and water heating, but has now-a-days it has been replaced by LPG due to increase in family income and improvement in life style.

Energy use study conducted by Statistical Department of India showed that energy expenditure of wood in rural areas is Rs.1,227/family/year and in
urban areas is Rs.1,328/family/year because of consumption of more crop residues in rural area (Shonali, Pachauri et al., 2003).

IEO (2003) highlights the contribution of different energy sources to various countries of the world and it worked out a projection study for the forecast period 2025 to explain the global energy demand and to evaluate proper energy planning for the future.

Conclusion

From the literatures reviewed above, it is clear that there has hardly been any such work to explain firewood consumption in Tirunelveli district. This dissertation takes attempts to fill up the gap in the knowledge system by discussing firewood consumption patterns of rural and urban areas of Tirunelveli district.