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# Domestic energy consumption patterns in Uttara Kannada District, Karnataka State, India

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**Abstract**

Energy planning of any region should be based on existing levels of energy consumption. Sectorwise disaggregated information of energy usage is developed for the Uttara Kannada District to assist in the regional energy planning exercise. This paper provides comparative analyses of village level domestic energy consumption patterns across coastal, interior, hilly and plain zones considering regional and seasonal variations. Cooking, water heating and space heating are the major end use activities. The results, based on eighteen months of field research in five taluks of Uttara Kannada, reveal that the average energy consumption norm does vary significantly for cooking and water heating in various seasons across the zones. Among the five taluks, 90 villages (out of 119) and all divisions of Kumta town in the Kumta taluk and 190–220 randomly selected households in selected villages of Sirsi, Mundgod, Siddapur and Ankola were studied. A survey of 1304 households from 90 villages in the Kumta taluk shows that most of them still use traditional stoves for cooking (97.92%) and water heating (98.3%). Average consumption (kg/person/day) for cooking ranges from $2.01 \pm 1.49$ (coastal) to $2.32 \pm 2.09$ (hilly). Seasonwise cooking fuel wood requirement for coast and hilly zones, ranges from 1.98 and 2.22 (summer) to 2.11 and 2.51 (monsoon), respectively, while for water heating (for bath and washing), it ranges from $1.17 \pm 0.02$ (coast) to $1.63 \pm 0.05$ (hilly). Seasonal variation is evident from the range 1.12 and 1.53 (summer) to 1.22 and 1.73 (monsoon) for coastal and hilly zones, respectively. Analysis of other sources of energy for domestic purposes shows that kerosene is used for cooking and lighting in the coast. Kerosene consumption (l/person/month) for cooking ranges from 0.05 (hilly) to 0.34 (coast) and for lighting ranges from 0.75 (coast) to 0.99 (hilly). Availability of bioresources in hilly zone is the main reason for less consumption of kerosene for cooking. In the hilly zone, electrification of all households has not been possible, as they are

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scattered. Because of the erratic supply during all seasons (especially monsoon), electrified households also depend on kerosene for lighting. Based on fuel consumption norms (regionwise, seasonwise and end usewise), (a) the total fuel wood required (cooking, water heating, space heating, jaggery making and parboiling) works out to 1.668,698.23 tonnes/year, (b) the electricity demand, excluding irrigation, is about 32.65 million kWh/year and (c) the kerosene demand for cooking and water heating is about 15.86 million litres per year. 

*Keywords:* Energy efficiency; Household energy; Rural energy; Fuel wood; Per capita fuel consumption; Traditional stoves; Improved stoves; Sustainable development

## 1. Introduction

Energy is a fundamental and strategic tool even to attain the minimum quality of life. Sustainable development of a region depends critically on the health of renewable resources like soil, water, vegetation, livestock and genetic diversity. The integrated development of all these components is essential for environmentally sound development. The procurement of energy is also responsible in varying degrees for the ongoing deforestation, and loss of vegetation and top soil. While energy availability is a determining factor for agricultural productivity, traditional use of agricultural residues for energy production leads to soil impoverishment. The currently inefficient energy use in various sectors is certainly responsible for detrimental impacts on the environment. Hence, sound policy and management decisions must involve three elements: economics, environment and energy, which must be considered in the search for ways to improve current energy supplies. This necessitates promotion of conservation activities among local communities and application of traditional environmentally sound technologies.

Energy use patterns are closely linked to agro-climatic and socio-economic conditions. Hence, a detailed energy survey was conducted to understand the energy use patterns in various agro-climatic zones and seasons. Energy problems in rural areas are closely linked to soil fertility, landholding, livestock holding, etc. Energy planning of any region should be based on the existing levels of energy consumption. However, existing programs of development lack a disaggregated information base. Regional developmental activities have to be based on detailed information from each sector. In this direction, we conducted a detailed investigation of all sectors of the district to develop a disaggregated energy database. In this paper, household energy consumption patterns in five taluks of this district of Western Ghats, based on detailed field work for 18 months, and strategies to minimise the potentially negative impacts of the energy system on natural and human systems are discussed.

## 2. Objectives

The main objectives of this study are to:

1. determine the fuel consumption pattern in various agro-climatic zones of the Uttara Kannada District and determine the parameters involved in the variation and level of consumption,
2. measure and estimate the daily per capita fuel wood consumption in traditional and

improved stoves for cooking and water heating, and
3. identify different end uses and fuels used in rural and urban areas.

These studies are conducted to identify the basic energy utilising activities and end uses of energy in a region (zone) and suggest methods to meet the basic needs.‘

## 3. Methodology

An exploratory survey was conducted in various taluks initially. Socio-economic and energy data was collected from randomly selected samples in the Sirsi, Siddapur, Kumta and Ankola taluks. The preliminary results of the survey in households using fuel efficient stoves in the Sirsi and Kumta taluks showed fuelwood requirements for cooking (kg/person/day) to be 1.80 and 1.78 (summer) and 2.25 and 1.98 (monsoon), respectively.

Significant regional variation is noticed only during monsoon, mainly due to incessant rain (in hilly terrain) when people in Sirsi prefer hot food and water. During winter, fuel consumption at Sirsi and Kumta is 1.94 and 1.90 kg/person/day, respectively. Similar variation in fuel requirement is noticed for water heating. During monsoon and winter, hot water is preferred by villagers for bathing and washing, while in summer it is used only for bathing. Hence, fuel consumption is higher during monsoon — winter than summer. It is also noticed that fuel consumption for water heating during all seasons is higher at Sirsi than Kumta. The results also revealed that the levels of energy use and mix of energy sources depend on climatic and geographic factors. In order to get an insight into the energy consumption pattern and extent of variation due to these factors in the domestic sector, detailed energy surveys were conducted in the district, consisting mainly of secondary and primary data collection.

### *3.1. Collection of secondary data from Government agencies*

1. Landholding particulars (agriculture, horticulture, etc.) for each household were collected from Village Accountants' offices (14 offices covering all villages in Kumta, 6 in Sirsi covering 36 villages, 2 in Mundgod covering 12 villages and one in Ankola covering 10 villages. Out of these, Kumta and Ankola represent the coastal zone, Sirsi the hilly zone and Mundgod the plain zone).
2. Data on villagewise demography and occupational and infrastructural facilities was collected from the Tahsildar's office at the respective Taluk headquarters, the District Statistical Office at Karwar and the Directorate of Census Operation, Bangalore,
3. Data on livestock population, etc. was collected from the respective veterinary departments of each taluk, and
4. Villagewise land use maps were collected from the Survey of Land Settlement and Records Office (Revenue Department).

### *3.2. Collection of primary data*

The secondary information was analysed to select households for stratified sampling (based on landholdings, community etc.) for the energy survey. Households in each village were categorised into landless, small, medium and large farmers based on the landholdings. Under each category, households were grouped communitywise, and samples were selected from each category.

### 3.3. Detailed investigation of energy consumption pattern

The Kumta taluk was considered to study intra-taluk variation. It was divided into three zones, viz. (a) villages along the coast — Aghnashini, Kagal, Gokarna, Kodibag etc., (b) villages in the interior — Hegde, Divgi, Manaki etc. and (c) villages in the hilly area — Yana, Sandolli, Morshe, Santeguli etc. 92 villages and Kumta town were chosen to represent all three zones with the rural and urban population of the Kumta taluk. In each village, representative households of all communities and different landholding categories were chosen for the fuel consumption survey. Data on seasonal fuel procurement and consumption was also collected. The classification adopted based on landholding is: (i) landless, (ii) marginal farmers (0–0.5 ha), (iii) small farmers (0.5–1 ha), (iv) medium farmers (1–1.5 ha), (v) large farmers (1.5–2.5 ha) and (vi) very large farmers ($>2.5$ ha), keeping in mind the fragmented landholding scenario in the thickly populated coastal taluks of the district.

## 4. Study area

The study was conducted in the Kumta (Longitude 74° 24′ to 74° 45′ E, Latitude 14° 17′ to 14° 35′ N ), Sirsi (74° 35′ to 78° 5′, 14° 27′ to 14° 48′), Mundgod (74° 52′ to 75° 7′, 14° 42′ to

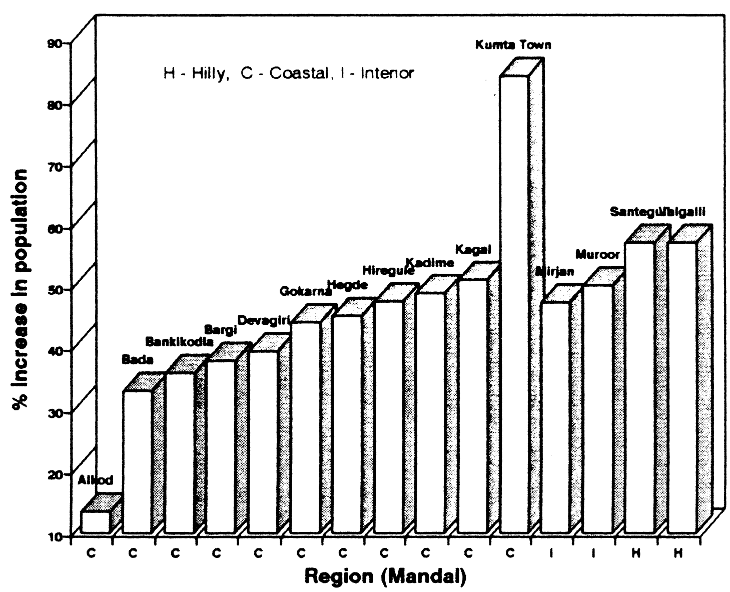


Fig. 1. Percentage population increase mandalwise and regionwise (1951–1991).

15° 04′) and Ankola (74° 18′ to 74° 43′, 14° 29′ to 14° 48′) taluks of the Uttara Kannada district (Fig. 1). Ankola and Kumta represent the coastal region, Mundgod the plain region and Sirsi the hilly region. In terms of bioresource availability, Kumta, Ankola and Mundgod are categorised as bioresource scarce and Sirsi as bioresource surplus regions.

## 5. Literature survey

### *5.1. Energy studies in India*

#### *5.1.1. ESCI study*

The first attempt to estimate and forecast total energy consumption and sources of supply was made by a 1965 Energy Survey Committee of India (ESCI). Data on consumption of non-commercial fuels was derived from the 1962 All India Sample Surveys of Rural Households and the 1958 Household Sample Surveys in Bombay, Calcutta and Delhi, conducted by the National Council of Applied Economic Research [1]. The study analysed the consumption trends of commercial sources of energy, viz., coal, oil and electricity in relation to economic growth and GNP. It has also estimated the consumption of non-commercial sources of energy, including firewood, and animal and agricultural wastes. The energy demand till 1980–81 was projected. It also conducted a survey of rural energy consumption of traditional and non-commercial energy sources. The Committee reported that twelve million tonnes of agricultural wastes were burned each year, largely in villages [2].

The surveys estimated average per capita domestic energy consumption to be 0.38 and 0.40 tonne of Coal Replacement (TCR) in the rural and metropolitan areas, respectively. Income elasticity of demand for domestic energy was estimated only for city dwellers and was found to be 0.4 for the group with per capita income above Rs. 300 each year. Since energy use estimates for urban areas, other than the three metropolitan cities, were not available, the Committee assumed it to be 0.39 TCR per capita. It also assumed that energy consumption during the preceding decade had increased by 4.5%, equivalent to the income elasticity of energy demand in cities. The past per capita energy use patterns were reconstructed on that basis. This data and rural and urban population estimates were used to determine the total domestic energy consumption. To determine the non-commercial energy use, the commercial energy consumption (for which relatively better data was available) was deducted from the estimated total energy consumption. Within the non-commercial sources, the estimated contributions of fuel wood, animal dung and agricultural residues were based on the assumption that their relative shares did not change over time. To project the energy demand till 1980–81, the Committee assumed that the:

- average per capita energy consumption was 0.38 and 0.39 TCR in rural and urban areas, respectively,
- per capita energy consumption would rise by 25 and 15% in rural and urban areas, respectively [This was based on the assumptions that (i) the total real per capita consumption may nearly double; (ii) electricity may be more widely available so that around 50% of the urban and 30% of the rural population would belong to the category with

income elasticity of energy demand; and (iii) the income elasticity of energy demand across the country would be 0.5%]. It may, however, be noted that the Committee's report is not specific on this point, and the reference seems to be to the average income elasticity of energy demand. It may also be noted that the NCAER earlier estimated the income elasticity of commercial energy demand in rural areas at 0.18–0.20 [3],
- commercial energy consumption would double every ten years, as in the past and
- the use of farm residues would increase in proportion to the expected increase in agricultural output, but the proportionate contribution of fuel wood and dung cake in the remaining non-commercial energy use would stay at the 1963 level.

During 1961–81, the total energy demand was expected to increase by 94%, with the demand for electricity, coal and oil expected to increase by more than 11, 10 and 5 times, respectively, while commercial energy as a whole was expected to increase by 6 times. Compared to that, the demand for non-commercial energy, fuel wood and dung cake was expected to increase by only 43, 31 and 17%, respectively. A perusal of the data also shows that within the non-commercial group, fuel wood's share was expected to decline from 65 to 60%, whereas the share of farm residues was expected to increase to 28 from 20%.

The Committee with the expectation of a major shift towards commercial energy sources, suggested that growth in non-commercial energy use should be curbed, and measures to achieve that objective included:

1. enhanced production and subsidised supply of commercial energy in general, and soft coke briquettes, in particular, and
2. imposition of octroi duties and other taxes on fuel wood.

The Committee did, however, emphasise planned development of non-commercial energy sources. For instance, it suggested that vigorous measures be adopted to enhance fuel wood production. A specific suggestion was to set up a fuel wood division in the then Ministry of Food and Agriculture. However, such administrative actions could hardly be expected to lead to a developed fuel wood market. Similarly, octroi duties on fuel wood, even if feasible, could not be expected substantially to reduce illicit cutting, inefficient use or even misuse of the material (at the same time, the suggestion to enhance fuel wood output should be welcomed, as enhanced production of soft coke briquettes could possibly not be a financially, socially and environmentally preferred alternative). The Committee's demand forecasts were not validated—the observed consumption levels in 1963 were close to the expectations for 1961, and the 1979 observations were substantially below those for 1981. At the same time, animal dung has been an exception, as its observed use in 1979 was significantly higher than the estimate for 1981. This may mean that dung continued to be a preferred source of household energy due to its inherent characteristics such as slow burning, relatively assured supply and the perception of dung work as an integral part of household chores, even in land owning families in rural India.

#### *5.1.2. NCAER study*

The NCAER also used the results of their 1962 survey to project the energy demand of rural households up to 1976. It was assumed that the:

- rural population by the mid 1970s would be around 477 million,
- per capita income during 1962–76 would increase by about 70%,
- rural areas income elasticity of demand for commercial fuels would be 0.18–0.20 [3], and
- besides the income effect, consumer preferences would shift towards commercial fuels by 5–7%.

However, the Council's forecast did not come true, mainly due to absolute shortages of non-commercial fuels. Therefore, the forecast was reassessed with additional assumptions that:

- fuel wood supply from forest and non-forest areas could be around 70 mt (million tonnes) a year as estimated by the Ministry of Food and Agriculture [4],
- fuel wood consumption in urban areas would be negligible,
- use of crop residues as fuels should be restricted to 17 mt to enhance their use for compost making,
- success of the scheme to move milk colonies from cities would limit animal dung use to rural areas,
- soft coke use would be enhanced to meet shortfalls in supply of fuel wood and agricultural residues,
- around 202,000 villages would be electrified and 1.77 tWh a year would be available in rural areas,
- effective per capita consumption of lighting energy in rural areas would increase from 1 to 6 kWh, and
- kerosene supply would be 8–9 mt, of which about 6 mt would be available to rural households.

*5.1.3. Fuel Policy Committee*

In 1974, the Fuel Policy Committee (FPC) estimated the household use of commercial and non-commercial fuels [5], using the data generated by NCAER surveys. It was also assumed that the annual per capita energy consumption was 0.38 and 0.40 TCR in rural and urban areas, respectively; and that fuel wood, animal dung and agricultural residues contributed 65, 15 and 20%, respectively, to the total non-commercial energy. With these assumptions and the estimated rural and urban population, domestic consumption of non-commercial and total energy during 1961–71 was reconstructed.

A comparative analysis of the ESIC and FPC studies shows that the actual increase in domestic energy use during 1961–71 was estimated at 22%, whereas an earlier Committee expected it to be 37%. Similarly, consumption of commercial energy in the domestic sector increased by only 70% against the earlier Committee's forecast of nearly 150%.

The FPC also forecast the demand up to 1991. It assumed that:

- per capita energy consumption may not change considerably,
- almost all urban and 70% of rural households would use electricity for lighting,
- about 20 per cent of rural households would use kerosene for lighting,
- nearly 60 and 10% of urban and rural households, respectively, would use kerosene for cooking,

- up to 1984, the shares of fuel wood, dung and agricultural residues in the non-commercial energy use would be the same as estimated by ESIC for 1963, and
- the absolute consumption of crop residues would stabilise, starting in 1984, whereas that of fuelwood and animal dung would stay in the same ratio as of 1984 (the ESIC had assumed that consumption of agricultural residues would increase in proportion to farm output).

The Committee's forecasts of household energy demand in 1991 are summarised as — electricity 25 tWh (25 MTCR — million tonnes of coal replacement), kerosene 6 mt (49.8 MTCR), soft coke 20 mt (30.0 MTCR), LPG 2 mt (16.6 MTCR), firewood 122 mt (115.9 MTCR), dung cakes 53 mt (21.2 MTCR) and agricultural residues 46 mt (43.7 MTCR).

The 1989 data with respect to household use of kerosene and LPG show that the forecasts for 1991 by the FPC may be fairly validated. Similarly, the 1984 electricity data shows that the observed use was comparable to the forecast. Comparable data for soft coke was not available. The FPC projections also show that, while commercial and total energy use were anticipated to increase by about 150 and 25%, respectively, non-commercial energy was expected to decline by 8–10% due to decline in the fuel wood and animal dung use. Such shifts from non-commercial energy sources are welcome to facilitate the formulation and execution of sustainable energy policies. However, an important issue at the same time is whether fuel wood should continue to be treated as non-commercial.

The Royal Commission on Agriculture in 1928 believed that the use of animal dung as fuel could be reduced with assured fuel wood supplies at reasonable prices, i.e. prices which the rural households can afford to pay. The reasoning seems to be more relevant at present than it was in the 1920s. The relevance of observing nature's rules is better and more widely appreciated than ever before. Those who burn animal dung seem to be aware, but can be better educated, of its opportunity cost. Since the society is to benefit by shifts from non-commercial to commercial, non-renewable to renewable energy sources and from animal dung to fuel wood, an important step must be to enhance fuel wood supplies beyond a critical minimum (there has been a policy emphasis on enhanced fuel wood production but the programmes and policies do not seem to match).

#### *5.1.4. National Commission on Agriculture*

The National Commission on Agriculture (NCA) in 1976 projected the fuel wood demand up to the year 2000 [6]. The Commission accepted the FPC's 1971 estimates of fuel wood consumption of 220 kg per capita, total 120 mt, but argued that 15–20% of that is first used as timber and then as fuel wood. Thus, the net per capita fuel wood use was estimated at about 194 kgs a year. It was assumed that starting around 1985, the per capita fuel wood consumption would decline at the rate of 1% per annum and may be about 166 kg by the turn of the century (the Commission has not stated the basis for the assumption). The demand projections estimated on that basis for fuel wood are 115.5 mt in 1970 and 1975, 128.8 mt in 1980, 141.4 mt in 1985 and 157.5 mt in 2000. The Commission did not expect an appreciable shift away from non-commercial fuels. Within that category, however, it suggested deliberate policy interventions to reduce the share of dung cake from 15 to 5 per cent. A large part of the gap caused by that was expected to be covered by enhanced availability of agricultural residues due to an anticipated increase in farm productivity [6].

### 5.1.5. Working Group on Energy Policy

A Working Group on Energy Policy (WGEP) in 1979 also adopted the FPC's methodology to reconstruct domestic energy use during 1954 and 1976. The group adopted a scenario approach to make a reference level and an optimum level forecast of domestic energy demand up to 2000. The Reference Level Forecast (RLF) pertained to a situation without additional policy efforts for demand and supply management. The first step was to estimate the number of households in 1976 which used electricity and kerosene for lighting; and LPG, kerosene, soft coke and non- commercial fuels for cooking. Following that, the group assumed that:

- the annual per capita energy consumption would continue to be 0.38 and 0.4 TCR in rural and urban areas, respectively;
- the number of electrified households would increase by 2.14, 3.6, 4.0 and 5.0 million during 1976–83, 1983–88, 1988–93 and 1993–2001, respectively;
- soft coke output would increase from 6.5 mt in 1963 to 9 mt, 14 mt and 30 mt in 1988, 1993 and 2000, respectively;
- the proportion of households using non-commercial fuels would decline to 70% in rural and 10% in urban areas by the turn of the century, which would be mainly due to enhanced kerosene consumption;
- LPG would be a perfect substitute for kerosene, and the growth in kerosene demand would be reduced in proportion to the indigenous production of LPG;
- both rural and urban per capita consumption of kerosene and soft coke for cooking would be 240 litres and 1.75 tonnes, respectively and
- the per capita consumption of kerosene and electricity for lighting would be 24 litres and 300 kWh in rural and 36 litres and 400 kWh in urban areas, respectively.

On the other hand, the Optimum Level Forecast (OLF) pertained to a situation where suggested policy interventions had been adopted and assumptions regarding the likely changes in the energy system validated. On the policy side, the group emphasised that the production potential of lands under forests, roadsides and tank bunds be harnessed. This was expected to enhance fuel wood supply beyond forecasted requirements. It was also argued that the financial resources required to enhance the soft coke output and its transport throughout the country be better used for improved land management [7].

The group's assumptions regarding the energy use system were the:

- efficiency of household electricity consumption would improve by 2.5, 5 and 10% by 1988, 1993 and 2001, respectively,
- appliances can and would be improved to enhance the consumption efficiency of fuelwood and agricultural residues by at least 2, 5 and 10% by 1988, 1993 and 2001, respectively,
- growth rate of soft coke production would be limited to 6.7%, the rate projected for 1982–1987, so that its output by 2000 would be limited to 16.75 mt rather than 30 mt estimated in the case of the RLF and its demand reduced by 1.25 and 7.25 mt (coal equivalent) by 1993 and 2001, respectively,
- by 2000, 8.7% of rural households could depend on kerosene for cooking against 22.3% estimated in the case of the RLF and the demand reduced by 0.91 and 1.24 mt by 1993 and 2001, respectively, and

- quantities of animal dung and agricultural residues used for cooking could stabilise at the 1983 level.

The resulting projections by the OLFs and RLFs for 1983 and 1988 are comparable. The 1993 OLFs and RLFs with respect to electricity, LPG, fuel wood, animal dung and agricultural residues are also comparable, but for kerosene and soft coke, the OLFs are substantially lower than the RLFs. More importantly, the two scenarios for 2001 are comparable only with respect to LPG and electricity, and the OLFs regarding fuel wood, kerosene and soft coke are substantially lower, while for dung cake and farm residues, they are substantially higher than the RLFs. Part of the reason for the divergent expectations may be due to substantially lower OLFs, compared to the RLFs, for commercial energy in 1993 and 2001. At the same time, the total non-commercial energy use visualised under the two scenarios is strictly comparable for all the reference years. Such results must raise a number of issues, including their value for policy making, the desirability of encouraging or even anticipating fuel wood substitution with animal dung and farm residues in spite of environmental concerns and the prospects of substantial increase in fuel wood outputs with marginal improvements in forest and non-forest wasteland management.

*5.1.6. Fuelwood Study Committee*

The Government of India formed a Fuel wood Study Committee in 1981 [8], which agreed with the OLFs of the 1979 Working Group but made some additional observations and assumptions on land availability and management for fuel wood production. A few of these are:

- Forests have not been managed for fuelwood supplied except for casual supervision to avoid the right holders' "excesses". However, 60 million ha (mha) of forest land could annually give at least 30 mt of recorded fuel wood output (against the current 15 mt) a year, i.e. output excluding removals by right holders. Another 30 mt is, and can continue to be, obtained from private lands, gardens and trees around houses; and about 25 mt may be available from social forestry in the near future.
- Private forests have been managed to raise industrial wood, but fuel wood is also produced and can be produced where required.
- With identification of appropriate tree species to minimise competition with field crops, training, demonstrations and incentives, farm plans may include fast growing trees to, at least, meet family needs for fuel wood.
- Large tracts of low productivity land without clearly defined ownership or organised management, particularly in arid and semi-arid tracts, primarily support scattered trees, bushes or shrubs. This land provided forage and substantial quantities of fuel wood to the rural areas, adjoining urban areas. Its scientific management is difficult due to undefined ownership and high biotic pressures, but its potential for enhanced fuel wood production is extremely high.

In essence, the Committee emphasised an integrated approach to enhance biomass production. Fuel wood plantations at the rate of 1.5 mha a year were considered an absolute necessity. It was estimated that at least 20 mha, comprising wastelands, degraded forests, roadsides, railroad sides and canal banks, could be available for that purpose. It was also suggested that:

- the State agricultural universities should include fuel wood farming with their research and extension education programmes, and fuel wood should be included in major farming systems,
- schools, colleges, local bodies and voluntary organisations should be encouraged to raise tree nurseries,
- hypothecation of standing tree crops should be permitted to facilitate institutional finance for tree farmers, and
- tree growers should be assured remunerative prices and assistance for organised marketing of the produce, and the scope of the Agricultural Prices Commission should be enlarged for that purpose.

Though the emphasis once again was on supply management, it was considered feasible with better use of forest and non-forest wasteland, harnessing the complementarity between industrial wood and fuel wood production and inducing the farmers to grow fuel wood.

#### *5.1.7. Advisory Board on energy*

As an ongoing effort of national energy planning and to review continuously the energy situation in the country in the global context and for proposing future energy plans on an integrated and coordinated basis, the Government of India set up an Advisory Board on Energy (ABE) in March 1983. The ABE got a set of studies conducted regarding long term perspectives on demand and supply of various energy sources. The projected energy requirements for the year 2004–05 of the ABE were also computed based on two alternative growth rates of 4 and 5% and three alternative population values. The report postulates a minimum level of energy in the household sector, in terms of useful energy per person per day, as 620 kcal for cooking, 30 kcal for space heating and 30 kcal for lighting. The ABE estimated the demand for firewood based on an efficiency of 8% for wood stoves. Use of improved wood stoves will drastically reduce the projected demand of firewood [9].

The Advisory Board on Energy in 1985 presented an energy demand supply perspective for 2005. The forecasts for the household sector were based on:

- three alternative population levels; 1,003 million (m), 1,046 m and 1,115 m,
- a rural and urban population mix of 67.2 and 32.8%, respectively,
- a minimum per capita per day useful energy requirement of 630 kcal for cooking (computations based on the assumption that a 15 kg LPG cylinder with 154,500 kcal and 60% appliance efficiency would serve a five member household for 30 days, that is 618 kcal/day/person, assumed to be uniform throughout the country) and 30 kcal each for space heating and lighting,
- no significant change in relative share of cooking fuels,
- chulah efficiency at 8% (the need for improved efficiency was emphasised), and
- the per capita energy requirements for lighting as observed for greater Bombay.

The Board, however, made two important observations on the data. It would be undesirable to use 200 to 220 mt of dung cakes a year as fuel as that would reduce biogas production and manure. Thus, it was emphasised that dung use for household energy ought to be stabilised at 75–80 mt a year, i.e. at the 1979 level. This was considered possible with an enhanced supply of farm residues, which was considered feasible and desirable with an expected rise in farm outputs. It was also suggested that large scale commercial and industrial markets for farm residues should not be encouraged (NCAER, on the contrary, has emphasised the enhanced use of agricultural residues for compost making [3]). Alternatively, it was estimated that an additional 56.4 mt of fuel wood would stabilise animal dung use at 75–80 mt. This meant that 375 mt of fuel wood would be annually required by 2005. It was argued that this is feasible because the productivity of forest land could be raised by at least 300%, and at least 50% of India's forest and non-forest wasteland, estimated at 60 mha, could be used for fuel wood plantations [10]. However, it was feared that the fuel wood supplied in Uttar Pradesh, Punjab, Haryana, Tamil Nadu and Kerala may fall short of requirements. Hence, fuel efficiency measures, including briquetting of farm residues, enhanced soft coke production and their supply to deficit States, were recommended.

As the Indian economy grew at much lower rates during the final phase of the IVth and beginning of the Vth Five Year Plans, the FPC projections were found to be generally on the higher side. In order to review the energy demand projections afresh, the Planning Commission, Government of India constituted the 'Working Group on Energy Policy' (WEP) in 1977 with a view to undertake a "comprehensive review of the present energy situation in the light of recent developments, both within the country and outside, develop a perspective to next five to fifteen years and recommend appropriate policy measures for optimal utilization of available resources including non-conventional sources of energy". The WEP submitted its final report in 1979 [11]. As per the report, the total primary energy input during 1978–79 was estimated to be $8.87 \times 10^{18}$ Joules, of which non-commercial sources provided $4.42 \times 10^{18}$ Joules. Based on certain GDP, sectoral and population growth projections, the WEP had forecast the demand for both commercial and non-commercial sources of energy till the year 2000–01. Though both the trend and forecast show a gradual decrease in the relative share of non-commercial energy sources, it is certain that these sources will continue to dominate the rural energy sector for many decades to come.

#### *5.1.8. Perspective Planning Division, Planning Department, Government of Karnataka [12]*

In Karnataka, a study of domestic energy consumption patterns was conducted by the Perspective Planning Division, Planning Department, Government of Karnataka (1981), based on the 32nd round of the National Sample Survey (1977–78). 6745 (rural 4247, urban 2498) households covering all the 19 districts of the State were surveyed, which revealed that the per capita monthly expenditure on energy is a major expenditure both in rural and urban households. In rural households, it varied from Rs. 43.33 to Rs. 74.91, with a mean of Rs. 58.69. The firewood consumption varied from 13.69 to 73.55 kg per month (mean value 28.38 kg), and the kerosene used for lighting varied from 0.33 to 0.77 litres per month (mean value 0.54 litres).

In recent years, the Government of India has shown some interest in the promotion and utilisation of new and renewable sources of energy. It has formed a high powered Commission of Additional Sources of Energy (CASE) and Department of Non-Conventional Energy Sources (DNES) in 1981. While the CASE formulates the policies and programmes, the DNES is responsible for their implementation. By the end of March 1993, the DNES had constructed 0.17 million biogas plants (family size) against the targetted 0.15 million, saving 0.65 million tonnes of wood per year. Large size community and institutional biogas plants based on animal dung, industrial effluent and sewage are being constructed. 1009 such plants were operational as of March, 1993. The total number of family size biogas plants in India as of December 1996 was 2.15 million. The Department also launched the National Improved Chula (Woodstove) Programme in 1983. The total number of improved woodstoves in the country by March 1998 was 25,697,410. Their efficiencies are found to vary from 20 to 35%. There are more than 12,517 domestic and 6142 industrial solar water heating systems of different sizes operating in the country. More than 71 solar kilns, 61 solar crop dryers and 10,195 distillation systems are at various stages of completion. This does not include nearly 288,028 solar cookers in use. More than 1772 solar photovoltaic pumps have been installed in rural areas, providing water for drinking and micro-irrigation. 30,569 solar photovoltaic street lights, 42,845 domestic lighting systems and 88,920 solar lanterns have been provided in more than 450 villages, where electricity would perhaps never reach. Wind farms of a total capacity of 968 MW were installed in the coastal areas of Gujarat, Tamil Nadu, Maharashtra and Orissa. The DNES has also formulated an ambitious programme to establish 5000 MW of wind turbine capacity by the year 2000. The concept of harnessing locally available renewable energy sources in an integrated manner for supplementing energy supply options through Rural Renewable Energy Systems has been put into practice in about 392 villages of 13 States [13].

### *5.2. Studies by individual researchers*

As a first step to understand rural energy problems, ASTRA (Centre for Application of Science and Technology for Rural Areas) of IISc conducted a detailed survey in six villages in the Kunigal taluk (Tumkur district) in Karnataka during 1975–76 [14] based on observations, discussions, measurements and checks. Some of the findings are: (a) firewood is a dominant energy source (81.6%) used mainly for household activities, (b) cooking is a major activity consuming human and firewood energy, and efficiencies of chulahs are in the range of 5.08%, (c) human energy in h/day/household (especially women and children) was inefficiently used in firewood gathering (2.6), cooking (3.68), carrying food to farms (1.82), fetching water (1.53), taking cattle for grazing (5.54) etc., with the share of domestic burden between men, women and children being 24, 20 and 20%, respectively, (d) kerosene consumption for lighting is about 4.3 l/non-electrified house, 78% of the houses being non-electrified, and (e) industrial consumption is very small.

Roger Revelle [15] estimated the total energy utilised in rural India for the year 1971. As per his study and analysis, only 10% ($1.2 \times 10^{14}$ kcal/year) of the total energy ($11.42 \times 10^{14}$ kcal/year) in rural areas was derived from commercial sources, mainly contributed by kerosene, Diesel, chemical fertilizers and electricity from hydro sources. The remaining 90% is derived from traditional sources of energy, viz. human and animal labour, firewood, crop residues and animal wastes. Revelle concludes that rural people in India are tied to poverty and misery mainly because they use too little energy, and that too inefficiently, and secure all required energy by their own physical effort. A transformation of rural India, he suggested, can be brought about by increasing the quantity and improving the technology of energy use.

Gerald A. Leach [16] reviews the major features of residential energy use that have bearing on demand and supply options and also examines the profound changes that have occurred over the past few years in attitudes to wood fuel problems and their implications for energy policies and planning. Data from 15 country assessments show that households account for 30–35% of total energy use, compared to 25–30% for industrialised countries. The highest proportions are found in poorer countries, where households exclusively depend on biomass fuels.

Reddy and Krishna Prasad [17] in their critical analysis of the energy scene in India showed, with facts and figures, the highly skewed nature of the energy consumption patterns existing in the country. Their estimates on per capita energy consumption of the rural population, relying mainly on non-commercial energy sources, lies somewhere between 4.7 to 7 kWh/day, which is much below the satisfactory minimum of 36 kWh/day. In their opinion, the technologies appropriate for growth and development, biased in favour of rural India, may well require small scale decentralised energy systems, viz., biogas, solar and wind, with supplementary power coming, if necessary, from grid electricity. The authors also give a brief but exhaustive list of technological alternatives to harness new and renewable sources of energy, like biogas, solar and wind, and also methods to improve utilisation of animate sources of energy. The suggestions, if implemented at the National level, will not only improve the energy supplies needed but also enhance the quality of life and rural environment.

The energy use patterns of eight rural communities in the semi-arid agro-climatic zones were analysed by Bowonder et al. [18]. Irrigation is found to be the most significant factor influencing energy consumption and demand. There is a progressive trend towards monetisation of fuel wood, animal wastes and agricultural residues in these communities. There is emphasis on the need to generate disaggregated information on rural energy consumption patterns, though it involves collection of enormous data covering all households, income levels and landholding patterns for effective energy planning.

Energy use patterns and resource assessment of the village, Islamnagar, Bhopal district, Madhya Pradesh was done systematically by Maheshwari et al. [19]. This study shows that out of a total energy consumption of 2.46 GJ/capita/year, domestic activities consumed 2.08 GJ, of which cooking (mainly fuelwood) accounted for 2.03 and lighting 0.05 GJ.

Ravindranath and Chanakya [20] give a detailed picture of energy consumption in a village ecosystem. Their study in Ungra village, Karnataka shows that biomass fuels account for 81% of the village energy budget, while commercial energy accounts for 11%. The per capita consumption of energy is 13.1 GJ per year.

Ramakumar and Hughes [21] and Ramakumar [22] give a conceptual model of an Integrated Renewable Energy System for a village, where available biomass sources are converted to biogas to supplement the output of a sub-system designed to integrate solar radiation and wind resources.

The obvious feature of residential energy use in developing countries is the great variation in energy use and the mix of fuels. This diversity is apparent from National and regional averages. An attempt to quantify average consumption, based on nearly 350 household surveys and rough estimates for 88 countries by the United Nations Food and Agriculture Organisation (FAO) shows [23] higher consumption for cold, mountain areas (reflecting space heating needs) and warmer regions of sub-Saharan Africa and Latin America compared to North Africa, the Middle East and Asia (reflecting more abundant biomass resources). The lower proportions of biomass use in Latin America reflect greater rural incomes, infrastructure development and access to modern fuels. Elsewhere, biomass use is typically more than 90–

95% of total residential consumption, the remainder being kerosene (and occasionally electricity) for lighting. The heavy dependence on crop residues and animal wastes in Asia reflects low forest cover and farm tree resources. This study reveals a much greater variation at the local level, ranging from 2.4 to 59.2 GJ (150–3700 kgs fuel wood equivalent). In Nepal, a 25-village survey [24] shows per capita consumption ranging from 0.1 to 2.55 $m^3$. A study of 74 Indian villages [25–27] involving more than 5200 households, found the village average biomass fuel use to be 4–6 GJ per capita annually in 30% and 2–8 GJ in 65% of the villages, but the complete range was 1.5–20.5 GJ.

### 5.3. Fuel consumption pattern in Karnataka

State level energy consumption was studied before undertaking district/taluk level studies in order to know the trend in levels and types of energy consumption at the macro level. Sourcewise energy consumption in Karnataka reveals that 53.20% of the total energy is met by non-commercial sources of energy like firewood (43.60%), cow dung cake (1.40%) and agrowastes (8.20%), while commercial energy, like coal (5.80%), oil (11.60%), kerosene (2.60%), LPG (0.70%) and electricity (26.10%), constitute 46.80%. A significant part of these non-commercial energy sources cater the heating (domestic) needs of the rural population (about 70–80%), followed by village industries. We discuss demographic, land use and energy consumption patterns in the Kumta taluk in the following sections.

## 6. Data analyses

Per Capita Fuel Consumption (PCFC) is computed to

1. determine the fuel consumption pattern in various agro-climatic zones,
2. find the various parameters involved in the variation and level of consumption, and
3. estimate the daily per capita consumption of fuel wood in traditional and improved stoves for cooking and water heating.

### 6.1. Computation of PCFC

$$\mathrm{PCFC} = \mathrm{FC}/p$$

where FC = fuel consumed in kgs/day and $p$ = number of adult equivalents, for whom food was cooked.

Computation of PCFC considering the following:

1. More than one type of fuel is used for cooking and water heating in any household. The quantity of fuel consumed is determined by subtracting the weight of the remaining fuel from its initial weight. The daily consumption of different fuels is calculated separately from the fuel weights of the consecutive days.
2. These daily consumption values in each household are converted to their equivalent dry

weights using the measured moisture content values, which are then converted into equivalent value using the net calorific value of each type of residue. These are added to get the daily energy consumption for each household.

3. The daily energy consumption of each household is further converted to per adult energy consumption using the adult equivalent of the number of people, which is computed assuming the conversion factors listed below:
   Standard adult equivalents used in analysis;

| Family Size | Standard Adult Equivalent |
|---|---|
| Men 18–59 yr | 1 |
| Women 18–59 yr | 0.8 |
| Men > 59 yr | 0.8 |
| Women > 59 yr | 0.8 |
| Boys 5–18 yr | 0.5 |
| Girls 5–18 yr | 0.5 |
| Kids 1–5 yr | 0.35 |
| Child < 1 yr | 0.25 |

4. For each family, daily per adult energy consumption is computed seasonwise. The average value, standard deviation and maximum and minimum values are computed for annual and seasonal consumption.
5. The data is grouped based on household income, landholding category, community and village separately. All the above parameters were computed for these groups.

## 7. Results and discussion

### 7.1. Area and population

Detailed investigation of energy consumption is conducted in the Kumta taluk, which has 14 mandals [A mandal represents a cluster of villages. For administrative purposes, like land revenue collection etc., each taluk is divided into mandals (rural area) and towns (urban area)]. Out of 14 mandals, 10 are in zone 1 (coastal), 2 in zone 2 (interior) and 2 in zone 3 (hilly). Population in these mandals for the last four decades is listed in Table 1. It shows that mandals located in zone 1 have an overall increase in population of 78.845% during the period 1951–91, followed by 95.524% in zone 2 and 132% in zone 3. This is shown pictorially in Fig. 1.

Mandalwise, the number of persons and livestock per hectare have also been computed and listed in Table 2, which shows that mandals located in zone 1 are densely populated with 2.50 (Hiregutti mandal) to 19.50 (Kumta town) persons/ha (overall average is 5.31). This is followed by zone 2 with 1.02 (Mirjan) to 1.96 (Muroor) persons/ha (overall average is 1.35). Mandals located in zone 3 are least populated, having 0.38 (Santeguli) to 0.58 (Alkod) persons/ha (overall average is 0.35). In zone 1, livestock density ranges from 0.90 (Bargi) to 3.44 (Kumta town). The overall averages in zones 1 to 3 are 1.63, 0.70 and 0.24 respectively. Fig. 2 gives mandalwise population/ha. The percentage forest cover (Table 2) is 24.93% (zone 1), 76.44% (zone 2) and 89.34% (zone 3). These analyses clearly show that zone 1 is densely populated with humans and livestock. The human pressure on the environment in the coastal zone is reflected by less forest cover.

### 7.2. Landuse pattern

Villagewise landholding particulars for each household, collected from the respective Village Accountant's offices, were computerised. Table 3 lists aggregated mandalwise and communitywise landholding (in has) information, while Table 4 gives relative percentages. This reveals that Patgar with a share of 23.15% is a dominant agricultural community, followed by Brahmin (21.69%), Gouda (17.92%), Naik (17.30%) etc.

Table 1
Mandalwise population and its percentage increase during four decades

| | | Total population | | | | | % Increase in population | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone | Mandal | 1951 | 1961 | 1971 | 1981 | 1991 | 1951–61 | 1961–71 | 1971–81 | 1981–91 | 1951–91 |
| C | Alkod | 4860 | 4800 | 4614 | 5054 | 5611 | −1.23 | −3.88 | 9.54 | 11.02 | 13.38 |
| C | Bada | 3599 | 3862 | 4243 | 4978 | 5369 | 7.31 | 9.87 | 17.32 | 7.85 | 32.97 |
| C | Bankikodla | 3927 | 3992 | 4397 | 5042 | 6105 | 1.66 | 10.15 | 14.67 | 21.08 | 35.68 |
| C | Bargi | 3478 | 3887 | 4374 | 4871 | 5587 | 11.76 | 12.53 | 11.36 | 14.70 | 37.75 |
| C | Devagiri | 8800 | 9175 | 9547 | 11,085 | 12,253 | 4.26 | 4.05 | 16.11 | 10.54 | 39.24 |
| C | Gokarna | 5833 | 6569 | 7397 | 9081 | 10,412 | 12.62 | 12.60 | 22.77 | 14.66 | 43.98 |
| C | Hegde | 4790 | 5439 | 6135 | 7614 | 8704 | 13.55 | 12.80 | 24.11 | 14.32 | 44.97 |
| C | Hiregultti | 3805 | 4976 | 5847 | 6425 | 7235 | 30.78 | 17.50 | 9.89 | 12.61 | 47.41 |
| C | Kadime | 4556 | 4936 | 6033 | 7473 | 8872 | 8.34 | 22.22 | 23.87 | 18.72 | 48.65 |
| C | Kagal | 2533 | 2898 | 3565 | 4180 | 5146 | 14.41 | 23.02 | 17.25 | 23.11 | 50.78 |
| C | Kumta Town | 12,600 | 16,223 | 19,112 | 23,385 | 29,833 | 28.75 | 17.81 | 22.36 | 27.57 | 83.89 |
| I | Mirjan | 3113 | 4353 | 5038 | 5450 | 5902 | 39.83 | 15.74 | 8.18 | 8.29 | 47.26 |
| I | Muroor | 4058 | 4942 | 5973 | 7258 | 8119 | 21.78 | 20.86 | 21.51 | 11.86 | 50.02 |
| H | Santeguli | 4354 | 5327 | 6538 | 8358 | 10,109 | 22.35 | 22.73 | 27.84 | 20.95 | 56.93 |
| H | Valgalli | 3671 | 4833 | 6069 | 7071 | 8539 | 31.65 | 25.57 | 16.51 | 20.76 | 57.01 |
| | Total | 61,377 | 86,212 | 98,882 | 117,325 | 137,796 | | | | | |
| C | Coast | 58,781 | 66,757 | 75,264 | 89,188 | 105,127 | 13.569 | 12.743 | 18.500 | 17.871 | 78.845 |
| I | Interior | 7171 | 9295 | 11011 | 12708 | 14021 | 29.619 | 18.462 | 15.412 | 10.332 | 95.524 |
| H | Hilly | 8025 | 10160 | 12607 | 15429 | 18648 | 26.604 | 24.085 | 22.384 | 20.863 | 132.374 |

Table 2
Mandalwise number of persons/ha, livestock/ha and percentage forest cover

| | | | | | Total livestock | | Total livestock/ hect | | |
|---|---|---|---|---|---|---|---|---|---|
| Zone | Mandal | Persons/ha | Cattle | Buffalo | Cattle | Buffalo | Livestock | Total forest | % Forest cover |
| C | Bargi | 2.77 | 1347 | 319 | 0.73 | 0.17 | 0.90 | 599.80 | 32.32 |
| C | Hiregutt | 2.50 | 1818 | 370 | 0.85 | 0.17 | 1.02 | 631.56 | 29.40 |
| C | Kadime | 4.52 | 1227 | 219 | 0.99 | 0.18 | 1.17 | 243.20 | 19.61 |
| C | Bankikodla | 7.78 | 774 | 213 | 0.99 | 0.27 | 1.26 | 12.75 | 1.62 |
| C | Valgalli | 2.94 | 3711 | 388 | 1.51 | 0.16 | 1.67 | 1440.13 | 58.50 |
| C | Hegde | 5.71 | 2750 | 345 | 1.51 | 0.19 | 1.70 | 641.26 | 35.17 |
| C | Gokarna | 7.21 | 2757 | 450 | 1.62 | 0.26 | 1.89 | 479.51 | 28.20 |
| C | Bada | 6.25 | 2451 | 411 | 1.76 | 0.29 | 2.05 | 239.22 | 17.17 |
| C | Devagiri | 6.25 | 3116 | 491 | 1.95 | 0.31 | 2.26 | 335.75 | 21.03 |
| C | Kagal | 9.71 | 1613 | 498 | 1.77 | 0.55 | 2.31 | 223.18 | 24.43 |
| C | Kumta town | 19.50 | 4850 | 406 | 3.17 | 0.27 | 3.44 | | |
| I | Mirjan | 1.02 | 3020 | 441 | 0.38 | 0.06 | 0.43 | 6175.07 | 77.43 |
| I | Muroor | 1.96 | 3251 | 498 | 1.08 | 0.17 | 1.24 | 1963.85 | 65.12 |
| H | Santeguli | 0.38 | 4208 | 130 | 0.28 | 0.01 | 0.29 | 13272.3 | 87.99 |
| H | Alkod | 0.58 | 3494 | 509 | 0.83 | 0.12 | 0.95 | 12,930.01 | 88.13 |
| | Total | | 35537 | 5282 | | | | 39187.59 | |
| C | Coast | 5.31 | 20,900 | 3729 | 1.39 | 0.25 | 1.63 | 3761.47 | 24.93 |
| I | Interior | 1.35 | 8171 | 1155 | 0.61 | 0.09 | 0.70 | 10,179.26 | 76.44 |
| H | Hilly | 0.35 | 6466 | 398 | 0.23 | 0.01 | 0.24 | 25,246.86 | 89.34 |

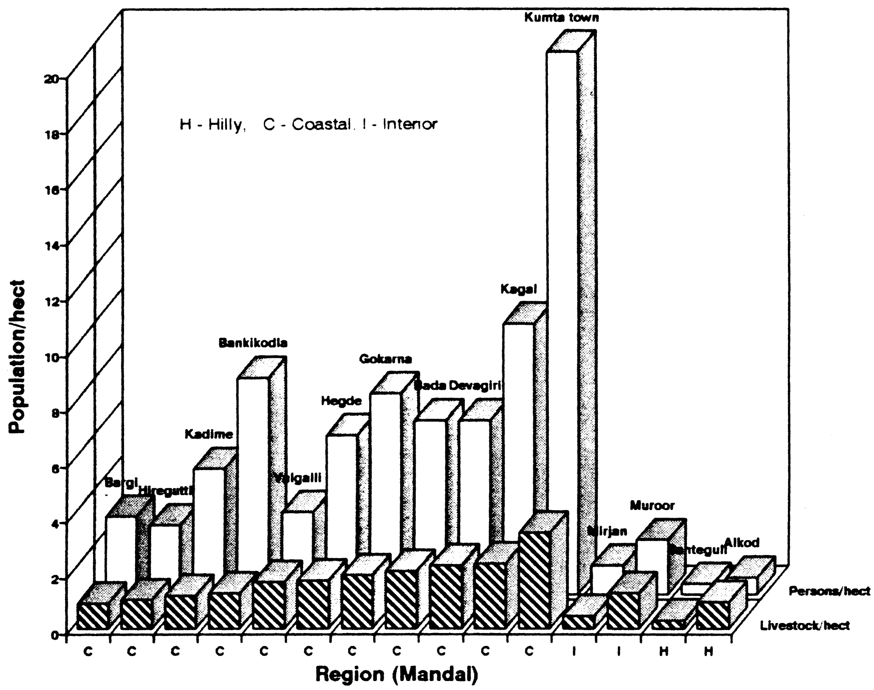


Fig. 2. Human and livestock density regionwise.

Land distribution among various categories of farmers is given in Table 5 and the corresponding percentages in distribution are listed in Table 6. It is seen that the number of households having 0–0.5 ha, in most of the mandals in zone 1, is more than 30%. It ranges from 34.60% (in Bargi) to 82.81% (Kumta town), while in zone 3, it ranges from 15.15% (Santeguli) to 31.86% (Alkod). This fragmented landholding scenario in the coastal zone can be attributed to dense population.

### 7.3. Energy demand assessment in Kumta taluk

We attempted to compute the desirable level of energy consumption in the domestic sector of the Kumta taluk. This will then be used, with the demographic and agro-climatic features of the district, to estimate the energy demand for various purposes.

There are various ways to calculate the useful domestic energy demand for cooking purposes. It can be based on either energy surveys or certain predetermined energy norms recommended by various agencies, most of which were based on cooking energy requirements in urban areas and, hence, are ad hoc. In this context, it is necessary to find a rational and reasonably accurate method of computing the domestic energy requirement taking into account seasonal and geographic factors. In this direction, an energy survey was conducted in 90 villages, as discussed earlier in Methodology. The questionnaire used consisted mainly of the following information:

Table 3
Mandalwise and communitywise landholding particulars (in ha) for Kumta taluk

| Zone | Mandal | PAT[a] | HB | GOU | NAI | GSB | TRA | GOVT | PT | MUK | FM | CH | OT2 | MU | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Kagal | 138.27 | 29.48 | 77.46 | 110.34 | 11.70 | 23.84 | 0.20 | 29.78 | 1.73 | 27.95 | 5.90 | 2.78 | 6.10 | 465.52 |
| C | Bargi | 418.27 | 18.89 | 25.85 | 163.77 | 12.48 | 8.74 | 0.61 | 6.45 | 2.66 | 83.83 | 2.86 | 0.92 | 8.56 | 753.89 |
| C | Kumta Town | 116.35 | 116.78 | 103.42 | 165.58 | 96.38 | 67.87 | 74.59 | 7.43 | 5.14 | 11.62 | 20.87 | 15.75 | 14.43 | 816.20 |
| C | Kadime | 129.29 | 171.83 | 241.58 | 203.54 | 23.18 | 44.05 | 22.88 | 10.21 | 15.12 | 19.99 | 8.47 | 13.20 | 0.47 | 903.79 |
| C | Valgalli | 190.11 | 328.05 | 150.25 | 119.56 | 39.44 | 30.64 | 4.52 | 22.64 | 39.55 | 2.18 | 8.62 | 8.16 | 0.28 | 944.00 |
| C | Bankikodla | 118.65 | 59.95 | 488.44 | 176.89 | 17.77 | 25.28 | 11.52 | 3.80 | 1.86 | 10.33 | 20.39 | 19.71 | 15.79 | 970.36 |
| C | Bada | 244.78 | 339.27 | 7.14 | 178.90 | 29.93 | 30.80 | 33.20 | 40.48 | 55.86 | 36.49 | 2.94 | 46.91 | 3.79 | 1050.50 |
| C | Gokarna | 162.17 | 215.01 | 469.35 | 95.28 | 37.25 | 34.40 | 19.94 | 3.65 | 13.45 | 4.31 | 0.74 | 10.35 | 1.77 | 1067.67 |
| C | Devagiri | 464.23 | 209.45 | 25.77 | 212.57 | 91.36 | 40.87 | 28.83 | 29.69 | 35.30 | 15.09 | 52.33 | 6.23 | 1.29 | 1213.00 |
| C | Hiregutti | 227.65 | 442.22 | 176.31 | 371.88 | 97.53 | 40.74 | 18.24 | 8.55 | 7.44 | 8.13 | 0.00 | 46.55 | 4.24 | 1449.49 |
| C | Hegde | 616.94 | 206.01 | 104.97 | 286.05 | 142.39 | 26.44 | 33.30 | 16.58 | 69.60 | 23.79 | 52.99 | 5.21 | 1.24 | 1585.52 |
| I | Muroor | 52.14 | 460.93 | 256.73 | 81.12 | 11.23 | 19.46 | 1.17 | 13.88 | 11.76 | 0.00 | 5.56 | 4.38 | 0.00 | 918.36 |
| I | Mirjan | 410.14 | 167.89 | 30.09 | 195.58 | 43.93 | 13.15 | 0.05 | 64.66 | 21.05 | 17.45 | 3.15 | 3.45 | 1.50 | 972.07 |
| H | Santeguli | 375.10 | 326.12 | 320.62 | 297.14 | 18.01 | 19.07 | 5.67 | 23.65 | 17.71 | 2.32 | 78.80 | 7.49 | 54.60 | 1546.31 |
| H | Alkod | 184.88 | 512.97 | 501.19 | 218.17 | 33.47 | 69.82 | 144.35 | 91.72 | 69.88 | 63.72 | 50.17 | 10.74 | 15.44 | 1966.51 |
| | Total | 3848.96 | 3604.85 | 2979.17 | 2876.37 | 706.08 | 495.17 | 399.05 | 373.16 | 368.08 | 327.18 | 313.79 | 201.83 | 129.50 | 16623.19 |

[a] PAT, Patgar; HB, Havyak Brahmin; GOU, Gouda; NAI, Naik; GSB, Gouda Saraswath Brahmin; MUK, Mukri; MU, Muslim; TRA, Traders; GOVT, Government; CH, Christian; PT, Palm Tappers; FM, Fishermen; OT, Others.

Table 4
Mandalwise and communitywise landholding particulars (in %) for Kumta taluk

| Zone | Mandal | PAT[a] | BR | GOU | NAI | GSB | TRA | GOVT | PT | MUK | FM | CH | OT2 | MU | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Kagal | 29.70 | 6.33 | 16.64 | 23.70 | 2.51 | 5.12 | 0.04 | 6.40 | 0.37 | 6.00 | 1.27 | 0.60 | 1.31 | 100.00 |
| C | Bargi | 55.48 | 2.51 | 3.43 | 21.72 | 1.66 | 1.16 | 0.08 | 0.86 | 0.35 | 11.12 | 0.38 | 0.12 | 1.14 | 100.00 |
| C | Kumta Town | 14.25 | 14.31 | 12.67 | 20.29 | 11.81 | 8.32 | 9.14 | 0.91 | 0.63 | 1.42 | 2.56 | 1.93 | 1.77 | 100.00 |
| C | Kadime | 14.30 | 19.01 | 26.73 | 22.52 | 2.56 | 4.87 | 2.53 | 1.13 | 1.67 | 2.21 | 0.94 | 1.46 | 0.05 | 100.00 |
| C | Valgalli | 20.14 | 34.75 | 15.92 | 12.67 | 4.18 | 3.25 | 0.48 | 2.40 | 4.19 | 0.23 | 0.91 | 0.86 | 0.03 | 100.00 |
| C | Bankikodla | 12.23 | 6.18 | 50.34 | 18.23 | 1.83 | 2.61 | 1.19 | 0.39 | 0.19 | 1.06 | 2.10 | 2.03 | 1.63 | 100.00 |
| C | Bada | 23.30 | 32.30 | 0.68 | 17.03 | 2.85 | 2.93 | 3.16 | 3.85 | 5.32 | 3.47 | 0.28 | 4.47 | 0.36 | 100.00 |
| C | Gokarna | 15.19 | 20.14 | 43.96 | 8.92 | 3.49 | 3.22 | 1.87 | 0.34 | 1.26 | 0.40 | 0.07 | 0.97 | 0.17 | 100.00 |
| C | Devagiri | 38.27 | 17.27 | 2.12 | 17.52 | 7.53 | 3.37 | 2.38 | 2.45 | 2.91 | 1.24 | 4.31 | 0.51 | 0.11 | 100.00 |
| C | Hiregutti | 15.71 | 30.51 | 12.16 | 25.66 | 6.73 | 2.81 | 1.26 | 0.59 | 0.51 | 0.56 | 0.00 | 3.21 | 0.29 | 100.00 |
| C | Hegde | 38.91 | 12.99 | 6.62 | 18.04 | 8.98 | 1.67 | 2.10 | 1.05 | 4.39 | 1.50 | 3.34 | 0.33 | 0.08 | 100.00 |
| I | Muroor | 5.68 | 50.19 | 27.96 | 8.83 | 1.22 | 2.12 | 0.13 | 1.51 | 1.28 | 0.00 | 0.61 | 0.48 | 0.00 | 100.00 |
| I | Mirjan | 42.19 | 17.27 | 3.10 | 20.12 | 4.52 | 1.35 | 0.01 | 6.65 | 2.17 | 1.79 | 0.32 | 0.35 | 0.15 | 100.00 |
| H | Santeguli | 24.26 | 21.09 | 20.73 | 19.22 | 1.16 | 1.23 | 0.37 | 1.53 | 1.15 | 0.15 | 5.10 | 0.48 | 3.53 | 100.00 |
| H | Alkod | 9.40 | 26.09 | 25.49 | 11.09 | 1.70 | 3.55 | 7.34 | 4.66 | 3.55 | 3.24 | 2.55 | 0.55 | 0.78 | 100.00 |
| | Total | 23.15 | 21.69 | 17.92 | 17.30 | 4.25 | 2.98 | 2.40 | 2.24 | 2.21 | 1.97 | 1.89 | 1.21 | 0.78 | 100.00 |

[a] PAT, Patgar; HB, Havyak Brahmin; GOU, Gouda; NAI, Naik; GSB, Gouda Saraswath Brahmin; MUK, Mukri; MU, Muslim; TRA, Traders; GOVT, Government; CH, Christian; PT, Palm Tappers; FM, Fishermen; OT, Others.

Table 5
Mandalwise and categorywise land distribution (frequency distribution) Kumta taluk

| Zone | Mandal | 0 ha | 0–0.5 | 0.5–0.75 | 0.75–1.25 | 1.25–1.75 | 1.75–2 | 2–4 | 4–6 | 6–8 | > 8 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Kagal | 0 | 616 | 163 | 52 | 70 | 27 | 19 | 6 | 3 | 0 | 956 |
| C | Bargi | 5 | 354 | 324 | 196 | 65 | 48 | 27 | 1 | 0 | 3 | 1023 |
| C | Devagiri | 3 | 589 | 268 | 147 | 58 | 29 | 37 | 2 | 1 | 1 | 1135 |
| C | Valgalli | 13 | 655 | 265 | 146 | 58 | 52 | 50 | 15 | 6 | 9 | 1269 |
| C | Bankikodla | 5 | 586 | 276 | 179 | 105 | 54 | 59 | 9 | 1 | 4 | 1278 |
| C | Hiregutt | 3 | 604 | 233 | 166 | 111 | 67 | 131 | 48 | 18 | 25 | 1406 |
| C | Kadime | 3 | 916 | 317 | 138 | 66 | 43 | 37 | 10 | 2 | 4 | 1536 |
| C | Hegde | 6 | 1170 | 254 | 112 | 74 | 57 | 102 | 26 | 4 | 4 | 1809 |
| C | Bada | 12 | 1073 | 329 | 178 | 124 | 47 | 72 | 7 | 4 | 3 | 1849 |
| C | Gokarna | 11 | 1223 | 280 | 122 | 74 | 42 | 94 | 22 | 10 | 3 | 1881 |
| C | Kumta town | 10 | 2255 | 252 | 85 | 40 | 19 | 45 | 6 | 3 | 8 | 2723 |
| I | Muroor | 3 | 491 | 256 | 164 | 74 | 68 | 85 | 13 | 4 | 0 | 1158 |
| I | Mirjan | 19 | 445 | 314 | 179 | 84 | 50 | 72 | 6 | 0 | 4 | 1173 |
| H | Santeguli | 1 | 163 | 177 | 200 | 164 | 122 | 201 | 36 | 9 | 3 | 1076 |
| H | Alkod | 1 | 418 | 248 | 207 | 147 | 85 | 155 | 31 | 10 | 10 | 1312 |

Table 6
Mandalwise and categorywise (%) land distribution in Kumta taluk

| Zone | Mandal | 0 ha | 0–0.5 | 0.5–0.75 | 0.75–1.25 | 1.25–1.75 | 1.75–2 | 2–4 | 4–6 | 6–8 | > 8 | or 1.75–8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Bargi | 0.49 | 34.60 | 31.67 | 19.16 | 6.35 | 4.69 | 2.64 | 0.10 | 0.00 | 0.29 | 7.72 |
| C | Hiregutt | 0.21 | 42.96 | 16.57 | 11.81 | 7.89 | 4.77 | 9.32 | 3.41 | 1.28 | 1.78 | 20.55 |
| C | Bankikodla | 0.39 | 45.85 | 21.60 | 14.01 | 8.22 | 4.23 | 4.62 | 0.70 | 0.08 | 0.31 | 9.94 |
| C | Valgalli | 1.02 | 51.62 | 20.88 | 11.51 | 4.57 | 4.10 | 3.94 | 1.18 | 0.47 | 0.71 | 10.40 |
| C | Devagiri | 0.26 | 51.89 | 23.61 | 12.95 | 5.11 | 2.56 | 3.26 | 0.18 | 0.09 | 0.09 | 6.17 |
| C | Bada | 0.65 | 58.03 | 17.79 | 9.63 | 6.71 | 2.54 | 3.89 | 0.38 | 0.22 | 0.16 | 7.19 |
| C | Kadime | 0.20 | 59.64 | 20.64 | 8.98 | 4.30 | 2.80 | 2.41 | 0.65 | 0.13 | 0.26 | 6.25 |
| C | Kagal | 0.00 | 64.44 | 17.05 | 5.44 | 7.32 | 2.82 | 1.99 | 0.63 | 0.31 | 0.00 | 5.75 |
| C | Hegde | 0.33 | 64.68 | 14.04 | 6.19 | 4.09 | 3.15 | 5.64 | 1.44 | 0.22 | 0.22 | 10.67 |
| C | Gokarna | 0.58 | 65.02 | 14.89 | 6.49 | 3.93 | 2.23 | 5.00 | 1.17 | 0.53 | 0.16 | 9.09 |
| C | Kumta town | 0.37 | 82.81 | 9.25 | 3.12 | 1.47 | 0.70 | 1.65 | 0.22 | 0.11 | 0.29 | 2.97 |
| I | Mirjan | 1.62 | 37.94 | 26.77 | 15.26 | 7.16 | 4.26 | 6.14 | 0.51 | 0.00 | 0.34 | 11.25 |
| I | Muroor | 0.26 | 42.40 | 22.11 | 14.16 | 6.39 | 5.87 | 7.34 | 1.12 | 0.35 | 0.00 | 14.68 |
| H | Santeguli | 0.09 | 15.15 | 16.45 | 18.59 | 15.24 | 11.34 | 18.68 | 3.35 | 0.84 | 0.28 | 34.48 |
| H | Alkod | 0.08 | 31.86 | 18.90 | 15.78 | 11.20 | 6.48 | 11.81 | 2.36 | 0.76 | 0.76 | 22.18 |
| | | 0.44 | 53.55 | 18.33 | 10.52 | 6.09 | 3.75 | 5.49 | 1.10 | 0.35 | 0.38 | 11.07 |

Household: number of members (male, female and children), educational background, income and landholding particulars.
Devices: types of commercial and non-commercial devices, purpose and duration.
Livestock: number and type, seasonal fodder and feed requirement, grazing particulars and dung yield (seasonal) and usage.
Fuelwood: mode of collection, quantity per season, types, place of collection, seasonal fuel wood consumption (by recall in most households and actual measurement in at least 5 households representing each landholding category) for cooking, water heating and other purposes like space heating etc.
Agriculture: animate and inanimate sources of energy requirement for various operations, type of crop, productivity etc.
Household industry: fuel requirements in jaggery-making, arecanut (red variety) preparation etc.
Efficient devices: perception about energy efficient devices and new sources of energy.

Data from 1304 households of 90 villages (out of 119) were collected during 18 months of field work covering 88% of the villages in zone 1, 68% in zone 2 and 70% in zone 3. The role of climatic and geographic factors on levels of energy consumption is explored in the following section.

### *7.4. Seasonal and regional variation in energy consumption*

Fuel wood is collected mainly from nearby forests in zone 3, while in zones 1 and 2, it is purchased from Government distribution outlets with the deficit collected from forests. It is

Table 7
Seasonwise and regionwise cooking fuel wood requirement in Kumta taluk

| Region | Zone | No. of samples | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| | | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Coast | 1 | 744 | 1.98 | 1.40 | 1.95 | 1.34 | 2.11 | 1.73 | 2.01 | 1.49 |
| Interior | 2 | 301 | 2.02 | 1.34 | 2.22 | 1.38 | 2.32 | 1.59 | 2.19 | 1.44 |
| Hilly | 3 | 259 | 2.22 | 1.56 | 2.23 | 1.94 | 2.51 | 2.77 | 2.32 | 2.09 |
| Total | | 1304 | | | | | | | | |
| Avg. | | | 2.07 | | 2.13 | | 2.31 | | 2.17 | |

mainly used for cooking, while horticulture residues (coconut husk, leaves etc.) and twigs are also used for water heating along with fuel wood in this region. Based on calorific values, all residues are converted to equivalent fuelwood value for computing per capita fuel wood consumption.

Out of the data collected from the 1304 households (stratified samples), 57.05% accounted for households in zone 1 (744), 23.08% for zone 2 and 19.87% for zone 3. Seasonwise and regionwise fuel consumption is computed for cooking (Table 7) and the bioenergy requirement for water heating (Table 8). Kerosene, LPG and biogas (for cooking) and kerosene and electricity (for lighting) are listed in Tables 9 and 10.

Table 7 illustrates seasonal and regional variation in fuelwood consumption. The average consumption ranges from $2.01 \pm 1.49$ (zone 1) to $2.32 \pm 2.09$ (zone 3) kg/person/day. The seasonwise fuelwood requirement for zones 1 and 3 ranges from 1.98 and 2.22 (summer) to 2.11 and 2.51 (monsoon) kg/person/day.

Table 8
Seasonwise and region wise water heating fuel wood requirement in Kumta taluk

| Region | Zone | No. of samples | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| | | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Coast | 1 | 744 | 1.12 | 0.50 | 1.18 | 0.55 | 1.22 | 0.54 | 1.17 | 0.02 |
| Interior | 2 | 301 | 1.23 | 0.66 | 1.35 | 0.79 | 1.46 | 0.89 | 1.35 | 0.09 |
| Hilly | 3 | 259 | 1.53 | 0.63 | 1.64 | 0.73 | 1.73 | 0.75 | 1.63 | 0.05 |
| Total | | 1304 | | | | | | | | |
| Avg. | | | 1.29 | | 1.39 | | 1.47 | | 1.38 | |

Table 9
Kerosene, biogas and LPG requirement for cooking in domestic sector

| | | Cooking energy | | | | | |
|---|---|---|---|---|---|---|---|
| | | Kerosene (cooking) (l/capita/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | |
| Region | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD |
| Coast | 744 | 0.34 | 0.79 | 0.23 | 0.76 | 0.02 | 0.10 |
| Interior | 301 | 0.21 | 0.69 | 0.26 | 0.79 | 0.01 | 0.05 |
| Hilly | 259 | 0.05 | 0.19 | 0.49 | 1.18 | 0.00 | 0.00 |
| Total | 1304 | | | | | | |
| Avg. | | 0.20 | | 0.33 | | 0.01 | |

Table 8 highlights the variation in fuelwood requirement for water heating (for bath and washing), which ranges from $1.17 \pm 0.02$ (zone 1) to $1.63 \pm 0.05$ (zone 3) kg/person/day. In zones 1 and 3, the seasonal variation ranges from 1.12 and 1.53 (summer) to 1.22 and 1.73 (monsoon) kg/person/day.

Table 9 gives the overall picture of other sources of energy for domestic purposes. In zone 1, kerosene is used for both cooking and lighting. Kerosene for cooking ranges from 0.05 (zone 3) to 0.34 (zone 1) l/person/month. Less consumption of kerosene in zone 3 compared to zone 1 is due to the availability of bioresources in sufficient quantity, while zone 1 is dependent on commercial sources of energy due to the scarcity of biofuels.

Kerosene for lighting ranges from 0.75 (zone 1) to 0.99 (zone 3) l/person/month. Zone 3 is

Table 10
Kerosene and electricity requirement for lighting in domestic sector

| | | Lighting energy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Kerosene (l/person/month) | | | | | | |
| | | Electricity (kWh/person/month) | | Electricity cost (Rs/capita/month) | | Summer | | Winter | | Monsoon | | Average |
| Region | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. |
| Coast | 744 | 2.50 | 2.62 | 2.81 | 4.10 | 0.69 | 0.46 | 0.77 | 0.47 | 0.78 | 0.49 | 0.75 |
| Interior | 301 | 2.61 | 3.08 | 2.66 | 3.95 | 0.80 | 0.45 | 0.84 | 0.44 | 0.84 | 0.47 | 0.83 |
| Hilly | 259 | 1.55 | 2.98 | 1.93 | 4.60 | 0.97 | 0.60 | 1.01 | 0.55 | 0.98 | 0.53 | 0.99 |
| Total | 1304 | | | | | | | | | | | |
| Avg. | | 2.22 | | 2.47 | | 0.82 | | 0.87 | | 0.87 | | 0.85 |

dependent more on kerosene for lighting due to the non-availability of electricity, as the households are spatially distributed, affecting electrification. This is apart from the erratic electricity supply during all seasons (more in monsoon). Electricity consumption for domestic purposes (irrigation not included) ranges from 1.55 (zone 3) to 2.50 (zone 1) kWh/person/month (Table 10).

### 7.5. Seasonwise and villagewise consumption of energy

The 90 villages surveyed were further grouped into 30 categories (based on location within 10–20 $km^2$ diameter — to distinguish villages closer to the sea and hilly tracts). Table 11 lists villagewise and seasonwise fuelwood consumption for cooking, ranging from 1.61 (Hegde, Masur, Bada etc.) to 2.89 (Antravalli, Bellangi etc.) kg/person/day.

Table 12 lists fuelwood consumption for water heating, which ranges from 0.88 (Kojjalli, Harnir etc.) to 2.09 (Hegle, Nadumuskeri etc.) kg/person/day.

Table 13 gives villagewise per capita consumption of kerosene, LPG and biogas for cooking (details of the number of households dependent on kerosene, biogas etc. will be discussed in the next section). Average kerosene and biogas consumption is about 0.15 l/person/month and 0.27 $m^3$/person/day, respectively. Kerosene for lighting ranges from 0.38 (Hedge, Masur — summer) to 1.40 (Yana, Jalghar — summer) l/person/month. Electricity consumption shows that villages such as Sandolli and Medine are still non-electrified.

### 7.6. Communitywise energy consumption

In order to see the role of culture and tradition in fuel wood consumption, the data was grouped based on community. The data reveals distinct differences in diet and cooking habits. Intercommunity variation in cooking fuel consumption, evident from Table 14, ranges from 1.62 (Ambiga community) to 2.62 (Achari community) kg/person/day. Table 15 lists fuel wood consumption for water heating, which ranges from 0.89 (Madival) to 1.59 (Havyak Brahmin) and 1.62 (Marathi community) kg/person/day.

Communitywise usage of kerosene, biogas and LPG (for cooking) and kerosene and electricity (for lighting) is listed in Table 16. It is seen that communities, such as Havyak Brahmin (HB) and Gouda Saraswath Brahmin (GSB), have switched to biogas, kerosene and LPG stoves for cooking. The shift from traditional to improved cook stoves (in certain households, kerosene stoves and/or biogas along with improved cook stoves) depends on educational background and economic soundness of the family. Economically and socially backward communities, such as Mukri and Kumbhi Marathi, still prefer traditional stoves (fuel is collected at zero cost), while economically and educationally advanced communities have switched over to biogas, LPG etc. In order to see the role of economic background, number of persons per household and type of devices in the consumption pattern, further analyses were performed.

### 7.7. Energy consumption based on landholding of households

Households are grouped based on landholdings, such as landless, 0–0.5, 0.5–0.75, 0.75–1.25,

Table 11
Villagewise and seasonwise cooking fuel wood consumption

| | | | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| Sl. No. | Village | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 1 | Aghnashini, Bargi, Paduvani | 66 | 1.92 | 0.96 | 1.93 | 0.98 | 1.97 | 0.97 | 1.94 | 0.97 |
| 2 | Aigalkurve, Savalkurve, Kelaginastala | 32 | 1.67 | 0.43 | 1.76 | 0.53 | 1.99 | 0.61 | 1.81 | 0.53 |
| 3 | Alvekode, Toppalgutta | 68 | 1.63 | 0.88 | 1.64 | 0.89 | 1.90 | 1.06 | 1.72 | 0.94 |
| 4 | Antravalli, Bellangi, Bandivala | 21 | 2.73 | 1.45 | 2.78 | 1.48 | 3.04 | 1.61 | 2.89 | 1.51 |
| 5 | Bada, Gudeangadi, Manikatta | 64 | 1.50 | 0.83 | 1.67 | 1.34 | 1.66 | 1.34 | 1.61 | 1.17 |
| 6 | Divgi, Siragunj, Manaki, Madakibail | 33 | 1.94 | 1.07 | 1.91 | 1.07 | 2.06 | 1.07 | 1.97 | 1.07 |
| 7 | Gokarna, Bankikodla, Bavikodla | 163 | 2.23 | 1.29 | 2.24 | 1.36 | 2.33 | 1.65 | 2.27 | 1.43 |
| 8 | Harita, Kadambale, Anegundi | 23 | 1.75 | 1.00 | 1.81 | 1.00 | 2.06 | 1.00 | 1.87 | 1.00 |
| 9 | Hebbail, Katgal, Yedtare | 29 | 1.82 | 0.79 | 1.98 | 0.86 | 2.31 | 0.91 | 2.04 | 0.85 |
| 10 | Hegde, Masur, Lukkeri | 86 | 1.52 | 1.06 | 1.50 | 1.07 | 1.82 | 1.28 | 1.61 | 1.14 |
| 11 | Hegle, Nadumaskeri, Harumaskeri | 14 | 2.15 | 0.52 | 2.17 | 0.52 | 2.17 | 0.54 | 2.16 | 0.53 |
| 12 | Holangadde, Halkar, Chitragi | 52 | 1.47 | 2.18 | 1.49 | 1.10 | 2.00 | 2.26 | 1.65 | 1.85 |
| 13 | Holegadde, Devgiri, Horbag, Harneer | 60 | 2.52 | 2.59 | 2.43 | 2.65 | 2.88 | 3.87 | 2.61 | 3.04 |
| 14 | Kagal, Hubbangeri | 52 | 1.95 | 0.88 | 1.94 | 0.88 | 1.94 | 0.89 | 1.94 | 0.88 |
| 15 | Kalve, Santeguli, Bastikeri, Basolli, | 70 | 1.94 | 2.29 | 2.52 | 3.03 | 2.91 | 4.45 | 2.46 | 3.26 |
| 16 | Koojalli, Kundgani, Harnir | 29 | 1.79 | 0.53 | 1.78 | 0.58 | 1.77 | 0.57 | 1.78 | 0.56 |
| 17 | Malavalli, Santhur, Bandivala | 18 | 2.02 | 0.46 | 2.07 | 0.39 | 2.07 | 0.39 | 2.05 | 0.41 |
| 18 | Medine, Santgal, Kavaladi | 20 | 2.35 | 0.76 | 2.42 | 0.77 | 2.53 | 0.81 | 2.43 | 0.78 |
| 19 | Mirjan, Nilkod, Kalkod, Tannirhonda | 52 | 2.28 | 0.69 | 2.25 | 0.77 | 2.26 | 0.74 | 2.26 | 0.73 |
| 20 | Morse, Moodagi, Mudanalli | 17 | 2.04 | 0.67 | 2.02 | 0.66 | 2.17 | 0.62 | 2.08 | 0.65 |
| 21 | Muroor, Kallabe, Karkimakki | 91 | 2.46 | 1.92 | 2.40 | 1.82 | 2.47 | 2.23 | 2.44 | 1.99 |
| 22 | Nagur, Kodkani, Masurkurve | 34 | 1.87 | 0.93 | 1.91 | 0.91 | 2.20 | 1.17 | 1.99 | 1.00 |
| 23 | Sandolli, Hiregutti, Ennemadi | 10 | 1.56 | 0.82 | 1.70 | 0.85 | 1.97 | 1.03 | 1.74 | 0.90 |
| 24 | Shirali, Kadime, Torke, Hoskeri | 32 | 2.44 | 1.94 | 2.63 | 2.31 | 3.18 | 3.48 | 2.75 | 2.58 |
| 25 | Talgod, Hervatte, Baggon | 61 | 2.52 | 1.24 | 2.57 | 1.23 | 2.61 | 1.25 | 2.57 | 1.24 |
| 26 | Unchalli, Urkeri, Gonehole, Honehalli | 23 | 2.90 | 1.12 | 2.83 | 1.15 | 2.93 | 1.40 | 2.85 | 1.22 |
| 27 | Valgalli, Harodi, Horbag | 33 | 1.54 | 0.84 | 1.64 | 0.89 | 1.81 | 1.02 | 1.66 | 0.92 |
| 28 | Yana, Uppinapattana, Jalghar | 39 | 1.97 | 1.17 | 1.91 | 1.19 | 2.08 | 1.27 | 1.99 | 1.21 |
| 29 | Yelwalli, Nilkod, Yeswanimule | 12 | 1.82 | 0.33 | 1.82 | 0.33 | 1.82 | 0.33 | 1.82 | 0.33 |
| | Total | 1304 | | | | | | | | |
| | Avg. | | 2.01 | | 2.06 | | 2.24 | | 2.10 | |
| | SD | | 0.38 | | 0.37 | | 0.41 | | 0.37 | |
| | Max. | | 2.90 | | 2.83 | | 3.18 | | 2.89 | |
| | Min. | | 1.47 | | 1.49 | | 1.66 | | 1.61 | |

1.25–1.75, 1.75–2 and >2 ha. In our sample, landless accounted for 2.68%, while families owning 0–0.5 ha accounted for 24.76%, 0.5–0.75 ha 32.13%, 0.75–1.25 ha 17.48%, 1.25–1.75 ha 6.53%, 1.75–2 ha 5.23% and households owning >2 ha 11.19%. Daily energy consumption for cooking, water heating and lighting was computed for each category. Seasonwise and

Table 12
Villagewise and seasonwise water heating fuel wood consumption

| | | | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| Sl. No. | Village | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 1 | Aghnashini, Bargi, Paduvani | 66 | 1.21 | 0.49 | 1.19 | 0.49 | 1.21 | 0.51 | 1.20 | 0.01 |
| 2 | Aigalkurve, Savalkurve, Kelaginastala | 32 | 1.02 | 0.34 | 1.13 | 0.38 | 1.21 | 0.37 | 1.12 | 0.02 |
| 3 | Alvekode, Toppalgutta | 68 | 0.99 | 0.49 | 1.02 | 0.48 | 1.13 | 0.52 | 1.05 | 0.02 |
| 4 | Antravalli, Bellangi, Bandivala | 21 | 1.60 | 1.28 | 1.90 | 1.58 | 2.07 | 1.85 | 1.86 | 0.23 |
| 5 | Bada, Gudeangadi, Manikatta | 64 | 1.13 | 0.39 | 1.21 | 0.66 | 1.21 | 0.65 | 1.18 | 0.12 |
| 6 | Divgi, Siragunj, Manaki, Madakibail | 33 | 0.94 | 0.46 | 1.04 | 0.49 | 1.43 | 0.86 | 1.14 | 0.18 |
| 7 | Gokarna, Bankikodla, Bavikodla | 163 | 1.20 | 0.44 | 1.24 | 0.47 | 1.23 | 0.46 | 1.22 | 0.01 |
| 8 | Harita, Kadambale, Anegundi | 23 | 1.16 | 0.00 | 1.23 | 1.00 | 1.46 | 0.00 | 1.28 | 0.47 |
| 9 | Hebbail, Katgal, Yedtare | 29 | 1.38 | 0.79 | 1.57 | 0.88 | 1.85 | 0.96 | 1.60 | 0.07 |
| 10 | Hegde, Masur, Lukkeri | 86 | 0.96 | 0.48 | 1.01 | 0.52 | 1.26 | 0.60 | 1.08 | 0.05 |
| 11 | Hegle, Nadumaskeri, Harumaskeri | 14 | 1.87 | 0.54 | 2.20 | 0.64 | 2.20 | 0.62 | 2.09 | 0.04 |
| 12 | Holangadde, Halkar, Chitragi | 52 | 0.93 | 0.36 | 0.97 | 0.36 | 0.98 | 0.35 | 0.96 | 0.00 |
| 13 | Holegadde, Devgiri, Horbag, Harneer | 60 | 1.19 | 0.53 | 1.27 | 0.57 | 1.27 | 0.56 | 1.24 | 0.02 |
| 14 | Kagal, Hubbangeri | 52 | 1.03 | 0.39 | 1.04 | 0.38 | 1.02 | 0.37 | 1.03 | 0.01 |
| 15 | Kalve, Santeguli, Bastikeri, Basolli | 70 | 1.79 | 0.50 | 1.82 | 0.55 | 1.79 | 0.60 | 1.80 | 0.04 |
| 16 | Koojalli, Kundgani, Harnir | 29 | 0.87 | 0.23 | 0.88 | 0.23 | 0.88 | 0.22 | 0.88 | 0.00 |
| 17 | Malavalli, Santhur, Bandivala | 18 | 1.59 | 0.52 | 1.88 | 0.61 | 1.90 | 0.57 | 1.79 | 0.04 |
| 18 | Medine, Santgal, Kavaladi | 20 | 1.90 | 0.49 | 2.06 | 0.64 | 2.25 | 0.76 | 2.07 | 0.11 |
| 19 | Mirjan, Nilkod, Kalkod, Tannirhonda | 52 | 0.99 | 0.28 | 0.98 | 0.28 | 0.99 | 0.28 | 0.99 | 0.00 |
| 20 | Morse, Moodagi, Mudanalli | 17 | 1.47 | 0.52 | 1.55 | 0.57 | 1.61 | 0.61 | 1.54 | 0.04 |
| 21 | Muroor, Kallabe, Karkimakki | 91 | 1.39 | 0.55 | 1.47 | 0.54 | 1.62 | 0.62 | 1.49 | 0.04 |
| 22 | Nagur, Kodkani, Masurkurve | 34 | 1.26 | 0.86 | 1.47 | 0.95 | 1.55 | 0.92 | 1.43 | 0.04 |
| 23 | Sandolli, Hiregutti, Ennemadi | 10 | 1.46 | 0.42 | 1.60 | 0.49 | 1.76 | 0.60 | 1.61 | 0.07 |
| 24 | Shirali, Kadime, Torke, Hoskeri | 32 | 1.28 | 0.46 | 1.32 | 0.48 | 1.34 | 0.48 | 1.31 | 0.01 |
| 25 | Talgod, Hervatte, Baggon | 61 | 1.37 | 0.71 | 1.49 | 0.84 | 1.48 | 0.80 | 1.45 | 0.05 |
| 26 | Unchalli, Urkeri, Gonehole, Honehalli | 23 | 1.55 | 0.65 | 2.03 | 0.86 | 1.78 | 0.76 | 1.79 | 0.09 |
| 27 | Valgalli, Harodi, Horbag | 33 | 1.08 | 0.51 | 1.17 | 0.41 | 1.32 | 0.52 | 1.19 | 0.05 |
| 28 | Yana, Uppinapattana, Jalghar | 39 | 1.44 | 0.78 | 1.59 | 0.99 | 1.69 | 0.99 | 1.57 | 0.10 |
| 29 | Yelwalli, Nilkod, Yeswanimule | 12 | 1.23 | 0.29 | 1.23 | 0.27 | 1.24 | 0.25 | 1.23 | 0.02 |
| | Total | 1304 | | | | | | | | |
| | Avg. | | 1.29 | | 1.40 | | 1.47 | | 1.39 | |
| | SD | | 0.28 | | 0.36 | | 0.36 | | 0.33 | |
| | Max. | | 1.90 | | 2.20 | | 2.25 | | 2.09 | |
| | Min. | | 0.87 | | 0.88 | | 0.88 | | 0.88 | |

Table 13
Villagewise kerosene, biogas and LPG consumption for cooking and, kerosene and electricity for lighting

| | | Cooking Energy | | | | | | Lighting Energy | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Kerosene (l/person/ month) | | | | | |
| | | Kerosene (l/person/ month) | | Biogas ($m^3$/person/ day) | | LPG (kg/person/ month) | | Electricity (kWh/person/) | | Electricity cost (Rs./person/ month) | | Summer | | Winter | | Monsoon | |
| Village | Samples $N$ | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Aghnashini, Bargi, Paduvani | 66 | 0.15 | 0.79 | 0.22 | 0.49 | 0.01 | 0.05 | 1.99 | 1.45 | 3.01 | 3.10 | 0.67 | 0.29 | 0.75 | 0.34 | 0.65 | 0.28 |
| Aigalkurve, Savalkurve, Kelaginastala | 32 | 0.13 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 2.21 | 1.85 | 2.03 | 2.31 | 0.94 | 0.39 | 0.90 | 0.37 | 0.88 | 0.36 |
| Alvekode, Toppalgutta | 68 | 0.24 | 1.12 | 0.25 | 0.47 | 0.04 | 0.16 | 3.43 | 3.21 | 3.73 | 4.75 | 0.60 | 0.49 | 0.61 | 0.48 | 0.77 | 0.57 |
| Antravalli, Bellangi, Bandivala | 21 | 0.13 | 0.31 | 0.00 | 0.27 | 0.03 | 0.15 | 2.41 | 2.94 | 2.05 | 3.34 | 0.79 | 0.56 | 0.79 | 0.56 | 0.72 | 0.61 |
| Bada, Gudeangadi, Manikatta | 64 | 0.30 | 0.85 | 0.38 | 0.75 | 0.01 | 0.06 | 2.99 | 2.32 | 2.34 | 1.57 | 0.69 | 0.31 | 0.77 | 0.32 | 0.65 | 0.29 |
| Divgi, Siragunj, Manaki, Madakibail | 33 | 0.18 | 0.41 | 0.27 | 0.39 | 0.00 | 0.00 | 1.78 | 2.08 | 2.43 | 2.82 | 0.46 | 0.41 | 0.47 | 0.42 | 0.47 | 0.49 |
| Gokarna, Bankikodla, Bavikodla | 163 | 0.54 | 0.96 | 0.10 | 0.38 | 0.02 | 0.09 | 1.85 | 2.21 | 2.16 | 2.60 | 0.70 | 0.42 | 0.86 | 0.46 | 0.86 | 0.45 |
| Harita, Kadambale, Anegundi | 23 | 0.00 | 0.00 | 0.35 | 0.77 | 0.00 | 0.00 | 1.44 | 2.00 | 2.03 | 3.00 | 0.94 | 0.00 | 0.94 | 0.00 | 0.95 | 0.00 |
| Hebbail, Katgal, Yedtare | 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.91 | 0.43 | 1.83 | 0.94 | 0.42 | 1.07 | 0.41 | 1.09 | 0.41 |
| Hegde, Masur, Lukkeri | 86 | 0.29 | 0.77 | 0.35 | 0.87 | 0.05 | 0.15 | 3.29 | 3.39 | 4.55 | 8.08 | 0.38 | 0.58 | 0.40 | 0.54 | 0.64 | 0.76 |
| Hegle, Nadumaskeri, Harumaskeri | 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.14 | 1.06 | 1.80 | 2.75 | 0.74 | 0.24 | 1.01 | 0.35 | 0.74 | 0.24 |
| Holangadde, Halkar, Chitragi | 52 | 0.16 | 0.41 | 0.28 | 0.64 | 0.01 | 0.04 | 2.55 | 1.53 | 2.26 | 1.80 | 0.64 | 0.22 | 0.67 | 0.26 | 0.67 | 0.24 |
| Holegadde, Devgiri, Horbag, Harneer | 60 | 0.43 | 0.85 | 0.54 | 0.97 | 0.04 | 0.19 | 4.19 | 4.38 | 4.15 | 4.99 | 0.84 | 0.44 | 0.75 | 0.45 | 0.90 | 0.49 |
| Kagal, Hubbangeri | 52 | 0.47 | 0.90 | 0.23 | 0.47 | 0.00 | 0.00 | 2.50 | 1.98 | 3.26 | 2.98 | 0.59 | 0.23 | 0.78 | 0.27 | 0.61 | 0.21 |
| Kalve, Santeguli, Bastikeri, Basolli, | 70 | 0.17 | 0.33 | 0.80 | 1.59 | 0.00 | 0.00 | 3.26 | 3.84 | 3.51 | 3.69 | 0.95 | 0.58 | 0.95 | 0.58 | 0.95 | 0.58 |
| Koojalli, Kundgani, Harnir | 29 | 0.37 | 0.95 | 0.29 | 0.50 | 0.00 | 0.00 | 1.92 | 1.82 | 1.82 | 1.84 | 0.82 | 0.19 | 0.82 | 0.19 | 0.82 | 0.19 |
| Malavalli, Santhur, Bandivala | 18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 1.28 | 0.39 | 0.98 | 0.86 | 0.30 | 1.20 | 0.65 | 0.86 | 0.30 |
| Medine, Santgal, Kavaladi | 20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.83 | 0.36 | 0.77 | 0.34 | 0.81 | 0.34 |
| Mirjan, Nilkod, Kalkod, Tannirhonda | 52 | 0.52 | 1.01 | 0.25 | 0.25 | 0.02 | 0.08 | 2.35 | 1.56 | 2.31 | 1.68 | 0.62 | 0.17 | 0.82 | 0.23 | 0.82 | 0.23 |
| Morse, Moodagi, Mudanalli | 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 1.01 | 0.51 | 1.44 | 1.15 | 0.61 | 1.15 | 0.61 | 1.12 | 0.59 |
| Muroor, Kallabe, Karkimakki | 91 | 0.06 | 0.28 | 0.67 | 6.21 | 0.00 | 0.00 | 3.96 | 3.97 | 3.92 | 5.54 | 1.05 | 0.53 | 1.03 | 0.53 | 1.09 | 0.54 |
| Nagur, Kodkani, Masurkurve | 34 | 0.03 | 0.18 | 0.10 | 0.49 | 0.00 | 0.00 | 1.47 | 2.46 | 2.15 | 4.33 | 0.86 | 0.35 | 0.81 | 0.26 | 0.84 | 0.33 |
| Sandolli, Hiregutti, Ennemadi | 10 | 0.00 | 0.00 | 0.43 | 0.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.28 | 0.39 | 1.31 | 0.38 | 1.31 | 0.38 |
| Shirali, Kadime, Torke, Hoskeri | 32 | 0.00 | 0.00 | 0.78 | 1.37 | 0.00 | 0.00 | 3.25 | 4.05 | 5.52 | 9.89 | 0.48 | 0.21 | 0.60 | 0.25 | 0.48 | 0.21 |
| Talgod, Hervatte, Baggon | 61 | 0.00 | 0.00 | 0.06 | 0.36 | 0.00 | 0.00 | 1.51 | 1.62 | 1.24 | 1.85 | 0.99 | 0.63 | 0.99 | 0.63 | 1.00 | 0.62 |
| Unchalli, Urkeri, Gonehole, Honehalli | 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.80 | 0.08 | 0.38 | 1.00 | 0.44 | 1.25 | 0.55 | 1.00 | 0.44 |
| Valgalli, Harodi, Horbag | 33 | 0.04 | 0.19 | 0.67 | 0.97 | 0.00 | 0.00 | 2.89 | 1.76 | 3.30 | 2.67 | 0.68 | 0.35 | 0.91 | 0.36 | 0.92 | 0.34 |
| Yana, Uppinapattana, Jalghar | 39 | 0.00 | 0.00 | 0.84 | 1.34 | 0.00 | 0.00 | 0.19 | 0.84 | 0.00 | 0.00 | 1.40 | 0.85 | 1.30 | 0.56 | 1.31 | 0.58 |
| Yelwalli, Nilkod, Yeswanimule | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.98 | 1.78 | 0.92 | 1.52 | 0.61 | 0.22 | 0.77 | 0.17 | 0.58 | 0.15 |
| Total | 1304 | | | | | | | | | | | | | | | | |
| Avg. | | 0.15 | | 0.27 | | 0.01 | | 1.90 | | 2.13 | | 0.81 | | 0.88 | | 0.85 | |
| SD | | 0.17 | | 0.27 | | 0.01 | | 1.21 | | 1.46 | | 0.23 | | 0.22 | | 0.21 | |
| Max. | | 0.54 | | 0.84 | | 0.05 | | 4.19 | | 5.52 | | 1.40 | | 1.31 | | 1.31 | |
| Min. | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.38 | | 0.40 | | 0.47 | |

Table 14
Communitywise and seasonwise cooking fuel wood consumption

| | | | Cooking fuelwood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| Sl. No. | Community | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 1 | Achari | 22 | 2.50 | 2.11 | 2.51 | 2.53 | 2.86 | 3.66 | 2.62 | 2.77 |
| 2 | Bhandari | 27 | 1.55 | 0.61 | 1.66 | 0.73 | 1.68 | 0.74 | 1.63 | 0.69 |
| 3 | Christian | 12 | 1.67 | 1.00 | 1.68 | 1.09 | 2.04 | 1.07 | 1.80 | 1.05 |
| 4 | Deshbhandari | 29 | 2.12 | 0.68 | 2.19 | 0.68 | 2.30 | 0.66 | 2.20 | 0.67 |
| 5 | Ambiga | 25 | 1.62 | 0.46 | 1.60 | 0.43 | 1.64 | 0.43 | 1.62 | 0.44 |
| 6 | Gavadi | 13 | 1.97 | 0.75 | 1.96 | 0.78 | 2.24 | 0.96 | 2.06 | 0.83 |
| 7 | Gouda | 300 | 2.24 | 0.91 | 2.27 | 0.91 | 2.33 | 0.96 | 2.28 | 0.93 |
| 8 | GSB | 69 | 1.93 | 1.71 | 1.94 | 1.87 | 1.98 | 2.23 | 1.95 | 1.94 |
| 9 | Gunaga | 4 | 1.86 | 0.06 | 1.98 | 0.21 | 1.86 | 0.06 | 1.90 | 0.11 |
| 10 | HB | 241 | 2.08 | 2.31 | 2.13 | 2.51 | 2.59 | 3.59 | 2.27 | 2.80 |
| 11 | Madival | 20 | 1.72 | 0.59 | 1.77 | 0.58 | 1.84 | 0.64 | 1.78 | 0.60 |
| 12 | Marathi | 43 | 2.07 | 0.92 | 2.21 | 0.93 | 2.27 | 1.02 | 2.18 | 0.96 |
| 13 | Mukri | 21 | 1.75 | 0.57 | 1.71 | 0.68 | 1.88 | 0.63 | 1.78 | 0.63 |
| 14 | Muslim | 22 | 1.73 | 0.32 | 1.90 | 0.32 | 1.95 | 0.52 | 1.86 | 0.39 |
| 15 | Naik | 223 | 1.93 | 0.94 | 1.96 | 1.01 | 2.03 | 0.99 | 1.97 | 0.98 |
| 16 | Others | 39 | 1.78 | 0.94 | 1.91 | 0.91 | 2.00 | 0.90 | 1.90 | 0.92 |
| 17 | Patgar | 173 | 2.09 | 1.36 | 1.98 | 1.06 | 2.14 | 1.11 | 2.07 | 1.18 |
| 18 | Shet | 21 | 2.02 | 2.18 | 2.15 | 2.60 | 2.68 | 3.81 | 2.28 | 2.86 |
| | Total | 1304 | | | | | | | | |
| | Avg. | | 1.92 | | 1.97 | | 2.13 | | 2.01 | |
| | SD | | 0.23 | | 0.23 | | 0.32 | | 0.25 | |
| | Max. | | 2.50 | | 2.51 | | 2.86 | | 2.62 | |
| | Min. | | 1.55 | | 1.60 | | 1.64 | | 1.62 | |

categorywise, fuel wood consumption for cooking, listed in Table 17, shows a variation from 1.83 (landless category) to 2.31 (for landholding $>2$ ha category) kg/person/day.

Fuel wood consumption for water heating, listed in Table 18, ranges from 1.23 (landless and 0.5–0.75 ha categories) to 1.60 (for very large farmers) kg/person/day. Kerosene, biogas and LPG (for cooking) and electricity and kerosene (for lighting) are listed in Table 19. Most of the households in all these categories still use firewood for cooking and a kerosene stove for boiling milk, tea preparation etc. Out of 1304 households only 18 use biogas for cooking, of which 6 households belong to the $>2$ ha and 4 to the 1.75–2 ha categories which also use kerosene stoves and fuel wood stoves on special occasions. Eight biogas units were distributed in the remaining 5 categories. Biogas for cooking ranges from 0.276 (landless category) to 0.775 ($>2$ ha category) $m^3$/person/day.

Table 15
Communitywise and seasonwise water heating fuel wood consumption

| | | | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer | | Winter | | Monsoon | | Average | |
| Sl. No. | Community | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 1 | Achari | 22 | 1.24 | 0.41 | 1.28 | 0.41 | 1.34 | 0.44 | 1.29 | 0.01 |
| 2 | Bhandari | 27 | 0.94 | 0.30 | 1.02 | 0.30 | 1.03 | 0.31 | 1.00 | 0.00 |
| 3 | Christian | 12 | 1.04 | 0.53 | 1.39 | 0.63 | 1.46 | 0.62 | 1.30 | 0.04 |
| 4 | Deshbhandari | 29 | 1.12 | 0.41 | 1.11 | 0.46 | 1.22 | 0.61 | 1.15 | 0.08 |
| 5 | Ambiga | 25 | 0.86 | 0.38 | 0.91 | 0.43 | 0.97 | 0.41 | 0.91 | 0.02 |
| 6 | Gavadi | 13 | 1.06 | 0.26 | 1.05 | 0.30 | 1.26 | 0.42 | 1.12 | 0.07 |
| 7 | Gouda | 300 | 1.31 | 0.58 | 1.44 | 0.71 | 1.47 | 0.71 | 1.41 | 0.06 |
| 8 | GSB | 69 | 1.19 | 0.40 | 1.22 | 0.38 | 1.26 | 0.34 | 1.22 | 0.02 |
| 9 | Gunaga | 4 | 0.87 | 0.08 | 0.91 | 0.10 | 0.93 | 0.12 | 0.90 | 0.02 |
| 10 | HB | 241 | 1.48 | 0.71 | 1.60 | 0.85 | 1.70 | 0.91 | 1.59 | 0.08 |
| 11 | Madival | 20 | 0.83 | 0.31 | 0.88 | 0.31 | 0.96 | 0.40 | 0.89 | 0.04 |
| 12 | Marathi | 43 | 1.53 | 0.65 | 1.61 | 0.76 | 1.71 | 0.86 | 1.62 | 0.09 |
| 13 | Mukri | 21 | 0.97 | 0.33 | 1.04 | 0.40 | 1.19 | 0.40 | 1.07 | 0.03 |
| 14 | Muslim | 22 | 1.27 | 0.33 | 1.25 | 0.34 | 1.29 | 0.32 | 1.27 | 0.01 |
| 15 | Naik | 223 | 1.15 | 0.57 | 1.19 | 0.59 | 1.26 | 0.64 | 1.20 | 0.03 |
| 16 | Others | 39 | 1.14 | 0.32 | 1.29 | 0.42 | 1.32 | 0.42 | 1.25 | 0.05 |
| 17 | Patgar | 173 | 1.03 | 0.54 | 1.08 | 0.55 | 1.15 | 0.58 | 1.09 | 0.02 |
| 18 | Shet | 21 | 1.17 | 0.38 | 1.14 | 0.41 | 1.16 | 0.39 | 1.16 | 0.01 |
| | Total | 1304 | | | | | | | | |
| | Avg. | | 1.12 | | 1.19 | | 1.26 | | 1.19 | |
| | SD | | 0.19 | | 0.21 | | 0.22 | | 0.20 | |
| | Max. | | 1.53 | | 1.61 | | 1.71 | | 1.62 | |
| | Min. | | 0.83 | | 0.88 | | 0.93 | | 0.89 | |

Electricity consumption seems to increase with an increase in landholdings. It ranges from 1.99 (landless) to 3.59 (>2 ha) kWh/person/month. Average usage for lighting has decreased with an increase in landholdings. It varies from 0.87 (landless), 0.86 (0–0.5 ha) to 0.75 (>2 ha) l/person/month.

### *7.8. Energy consumption analyses based on household income*

Based on income, the surveyed households are categorised into low (<Rs. 3600 per year), middle (Rs. 4000–10000 per year) and high (>Rs. 10000 per year) income categories. Pooled data shows 34.5% of the households belonging to low, 49% middle and 16.5% to high income categories.

Table 20 lists seasonwise fuel wood consumption for cooking purposes in the various income

Table 16
Communitywise kerosene, LPG and biogas for cooking and, kerosene and electricity for lighting

| | Cooking energy | | | | | | Lighting energy | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Kerosene (l/person/month) | | | | | |
| | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Electricity (kWh/person/month) | | Electricity (Rs./capita/month) | | Summer | | Winter | | Monsoon | |
| Community | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Achari | 0.10 | 0.24 | 0.161 | 0.549 | 0.00 | 0.00 | 3.61 | 3.61 | 4.46 | 6.37 | 0.91 | 0.38 | 0.95 | 0.41 | 0.90 | 0.37 |
| Bhandari | 0.37 | 0.79 | 0.212 | 0.608 | 0.00 | 0.00 | 2.33 | 1.80 | 2.28 | 1.98 | 0.78 | 0.40 | 0.86 | 0.44 | 0.82 | 0.41 |
| Christian | 0.23 | 1.03 | 0.190 | 0.628 | 0.10 | 0.25 | 5.24 | 5.35 | 7.57 | 7.21 | 0.48 | 0.42 | 0.50 | 0.43 | 0.50 | 0.43 |
| Deshbhandari | 0.18 | 0.44 | 0.184 | 0.252 | 0.00 | 0.00 | 1.53 | 2.11 | 1.57 | 2.28 | 0.92 | 0.41 | 0.96 | 0.32 | 0.95 | 0.44 |
| Ambiga | 0.05 | 0.16 | 0.000 | 0.000 | 0.00 | 0.00 | 0.72 | 0.93 | 0.78 | 1.31 | 0.52 | 0.20 | 0.58 | 0.21 | 0.50 | 0.22 |
| Gavadi | 0.18 | 0.45 | 0.095 | 0.330 | 0.00 | 0.00 | 2.52 | 2.17 | 2.27 | 1.95 | 0.87 | 0.67 | 0.91 | 0.66 | 0.99 | 0.69 |
| Gouda | 0.01 | 0.07 | 0.012 | 0.155 | 0.00 | 0.00 | 0.86 | 1.29 | 0.94 | 1.86 | 0.78 | 0.44 | 0.86 | 0.47 | 0.82 | 0.44 |
| GSB | 0.55 | 0.97 | 0.683 | 1.670 | 0.05 | 0.14 | 3.50 | 2.48 | 4.68 | 4.28 | 0.53 | 0.29 | 0.67 | 0.42 | 0.67 | 0.36 |
| Gunaga | 0.00 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 2.54 | 0.36 | 2.71 | 1.03 | 0.71 | 0.10 | 0.89 | 0.10 | 0.89 | 0.10 |
| HB | 0.51 | 0.91 | 0.637 | 0.576 | 0.04 | 0.15 | 5.05 | 3.91 | 5.86 | 6.80 | 0.92 | 0.71 | 0.93 | 0.63 | 0.95 | 0.66 |
| Madival | 0.15 | 0.42 | 0.000 | 0.000 | 0.00 | 0.00 | 2.37 | 1.31 | 1.72 | 1.62 | 0.43 | 0.36 | 0.51 | 0.40 | 0.56 | 0.34 |
| Marathi | 0.00 | 0.00 | 0.523 | 0.446 | 0.00 | 0.00 | 0.03 | 0.18 | 0.04 | 0.27 | 1.06 | 0.54 | 1.10 | 0.51 | 1.08 | 0.56 |
| Mukri | 0.00 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.76 | 0.95 | 0.18 | 0.55 | 0.70 | 0.33 | 0.75 | 0.33 | 0.85 | 0.42 |
| Muslim | 0.41 | 0.94 | 0.000 | 0.000 | 0.00 | 0.00 | 1.43 | 0.82 | 2.65 | 1.34 | 0.60 | 0.17 | 0.64 | 0.15 | 0.63 | 0.16 |
| Naik | 0.29 | 0.71 | 0.097 | 0.376 | 0.00 | 0.04 | 2.04 | 2.03 | 2.11 | 2.43 | 0.72 | 0.36 | 0.81 | 0.41 | 0.82 | 0.44 |
| Others | 0.60 | 0.93 | 0.235 | 0.705 | 0.02 | 0.08 | 2.31 | 2.65 | 1.91 | 3.46 | 0.84 | 0.50 | 0.89 | 0.50 | 0.96 | 0.46 |
| Patgar | 0.03 | 0.20 | 0.103 | 0.316 | 0.00 | 0.00 | 1.84 | 1.67 | 1.72 | 1.95 | 0.71 | 0.47 | 0.75 | 0.46 | 0.79 | 0.50 |
| Shet | 0.17 | 1.39 | 0.141 | 0.291 | 0.00 | 0.00 | 2.90 | 1.38 | 3.88 | 2.23 | 0.67 | 0.24 | 0.71 | 0.30 | 0.73 | 0.30 |
| Avg. | 0.21 | | 0.18 | | 0.01 | | 2.31 | | 2.63 | | 0.73 | | 0.79 | | 0.80 | |
| SD | 0.19 | | 0.21 | | 0.03 | | 1.37 | | 1.93 | | 0.17 | | 0.16 | | 0.17 | |
| Max. | 0.60 | | 0.68 | | 0.10 | | 5.24 | | 7.57 | | 1.06 | | 1.10 | | 1.08 | |
| Min. | 0.00 | | 0.00 | | 0.00 | | 0.03 | | 0.04 | | 0.43 | | 0.50 | | 0.50 | |

Table 17
Fuel wood consumption for cooking (kg/person/day) in various landholding categories

| Landholding (ha) | No. of samples | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Landless | 35 | 1.78 | 0.90 | 1.73 | 0.94 | 1.98 | 1.11 | 1.83 | 0.98 |
| 0–0.5 | 323 | 1.97 | 1.08 | 1.95 | 1.11 | 2.06 | 1.34 | 1.99 | 1.18 |
| 0.5–0.75 | 419 | 2.05 | 1.47 | 2.03 | 1.30 | 2.14 | 1.71 | 2.07 | 1.49 |
| 0.75–1.25 | 228 | 2.13 | 1.25 | 2.08 | 1.18 | 2.21 | 1.29 | 2.14 | 1.24 |
| 1.25–1.75 | 85 | 2.10 | 1.63 | 2.11 | 1.75 | 2.27 | 2.12 | 2.16 | 1.83 |
| 1.75–2 | 68 | 1.92 | 1.58 | 2.16 | 1.84 | 2.51 | 2.67 | 2.20 | 2.03 |
| > 2 | 146 | 1.94 | 1.95 | 2.30 | 2.54 | 2.70 | 3.57 | 2.31 | 2.69 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.98 | | 2.05 | | 2.27 | | 2.10 | |

categories. Most of the households are still dependent on fuel wood for cooking which ranges, on average, from 2.02 (high income) to 2.09 (low income) kg/person/day.

Table 21 provides the seasonal fuel requirement for water heating, with averages rangeing from 1.26 (low income) to 1.48 (high income) kg/person/day.

Table 22 is an attempt to see the role of income on type of fuel chosen for cooking and water heating in a household. Out of 18 biogas plants in our sample of 1304 households, 2

Table 18
Fuel wood consumption for water heating (kg/person/day) in various landholding categories

| Landholding (ha) | No. of samples | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Landless | 35 | 1.09 | 0.65 | 1.22 | 0.65 | 1.38 | 0.77 | 1.23 | 0.69 |
| 0–0.5 | 323 | 1.19 | 0.51 | 1.28 | 0.60 | 1.32 | 0.58 | 1.26 | 0.56 |
| 0.5–0.75 | 419 | 1.17 | 0.51 | 1.23 | 0.57 | 1.30 | 0.58 | 1.23 | 0.55 |
| 0.75–1.25 | 228 | 1.18 | 0.63 | 1.23 | 0.65 | 1.33 | 0.73 | 1.25 | 0.67 |
| 1.25–1.75 | 85 | 1.26 | 0.79 | 1.38 | 0.94 | 1.50 | 1.09 | 1.38 | 0.94 |
| 1.75–2 | 68 | 1.39 | 0.65 | 1.43 | 0.76 | 1.55 | 0.83 | 1.46 | 0.75 |
| > 2 | 146 | 1.52 | 0.73 | 1.63 | 0.80 | 1.64 | 0.79 | 1.60 | 0.77 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.26 | | 1.34 | | 1.43 | | 1.34 | 0.13 |

Table 19
Kerosene, biogas and LPG usage for cooking and, kerosene and electricity for lighting in various landholding categories

| | | Cooking Energy | | | | | | Lighting Energy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Kerosene (l/person/month) | | | | | | |
| | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Electricity (kWh/person/month) | | Electricity (Rs./capita/month) | | Summer | | Winter | | Monsoon | | Average |
| Landholding (ha) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. |
| Landless | 35 | 0.28 | 0.76 | 0.276 | 0.389 | 0.00 | 0.00 | 1.99 | 3.15 | 1.18 | 2.57 | 0.79 | 0.74 | 0.82 | 0.73 | 1.00 | 0.76 | 0.87 |
| 0–0.5 | 323 | 0.35 | 0.88 | 0.295 | 0.393 | 0.01 | 0.10 | 2.14 | 2.83 | 2.33 | 3.69 | 0.82 | 0.45 | 0.87 | 0.47 | 0.88 | 0.50 | 0.86 |
| 0.5–0.75 | 419 | 0.19 | 0.54 | 0.342 | 0.718 | 0.01 | 0.08 | 2.18 | 2.38 | 2.26 | 2.72 | 0.77 | 0.44 | 0.86 | 0.45 | 0.83 | 0.45 | 0.82 |
| 0.75–1.25 | 228 | 0.23 | 0.67 | 0.356 | 0.753 | 0.00 | 0.04 | 2.37 | 2.75 | 2.57 | 4.57 | 0.72 | 0.45 | 0.80 | 0.43 | 0.80 | 0.44 | 0.77 |
| 1.25–1.75 | 85 | 0.23 | 0.64 | 0.393 | 1.460 | 0.01 | 0.08 | 2.00 | 2.57 | 2.17 | 3.74 | 0.78 | 0.62 | 0.84 | 0.62 | 0.85 | 0.60 | 0.82 |
| 1.75–2 | 68 | 0.29 | 0.76 | 0.536 | 1.000 | 0.01 | 0.07 | 2.01 | 2.57 | 2.86 | 3.88 | 0.71 | 0.37 | 0.77 | 0.42 | 0.79 | 0.47 | 0.76 |
| > 2 | 146 | 0.23 | 0.67 | 0.775 | 1.410 | 0.02 | 0.10 | 3.59 | 3.82 | 4.73 | 7.06 | 0.76 | 0.69 | 0.75 | 0.56 | 0.75 | 0.57 | 0.75 |
| Total | 1304 | | | | | | | | | | | | | | | | | |
| Avg. | | 0.26 | | 0.42 | | 0.01 | | 2.33 | | 2.59 | | 0.76 | | 0.82 | | 0.84 | | 0.81 |

Table 20
Cooking fuel wood consumption in various household income categories

| | | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 215 | 2.05 | 0.96 | 2.05 | 0.97 | 2.17 | 1.01 | 2.09 | 0.98 |
| 4000–10000 | 639 | 2.03 | 1.36 | 2.03 | 1.26 | 2.12 | 1.53 | 2.06 | 1.38 |
| 10500–5 lakh | 450 | 1.97 | 2.13 | 1.99 | 2.57 | 2.11 | 3.61 | 2.02 | 2.77 |
| Total | 1304 | | | | | | | | |
| Avg. | | 2.02 | | 2.02 | | 2.13 | | 2.06 | |

were in low, 9 in middle and 7 in high income categories. Biogas consumption ranges from 0.200 (low income) to 0.596 (high income) $m^3$/person/day. Households using biogas for cooking also use kerosene to supplement their cooking fuel requirement. Kerosene used for cooking seems to increase with income, with 0.16 (low income), 0.29 (middle income) and 0.33 (high income) l/person/month.

Electricity consumption also shows a similar trend, ranging from 1.34 (low income), 2.21 (middle income) to 4.79 (high income) kWh/person/day. Usage of electric equipment, such as refrigerators, grinders, mixers, etc., is the main reason for higher consumption (excluding irrigation requirements) (Table 23).

### *7.9. Number of persons per household*

Out of 1304 households, 12.36% belonged to families with adult equivalents <3 per

Table 21
Fuel wood consumption for water heating purpose in various household income categories

| | | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 215 | 1.16 | 0.57 | 1.27 | 0.68 | 1.34 | 0.74 | 1.26 | 0.66 |
| 4000–10000 | 639 | 1.22 | 0.54 | 1.28 | 0.62 | 1.34 | 0.63 | 1.28 | 0.60 |
| 10500–5 lakh | 450 | 1.40 | 0.72 | 1.48 | 0.77 | 1.56 | 0.78 | 1.48 | 0.76 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.26 | | 1.34 | | 1.41 | | 1.34 | |

Table 22
Kerosene, biogas and LPG for cooking in various household income categories

| | | Cooking energy | | | | | |
|---|---|---|---|---|---|---|---|
| | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 215 | 0.16 | 0.67 | 0.200 | 0.892 | 0.00 | 0.00 |
| 4000–10000 | 639 | 0.29 | 0.73 | 0.453 | 0.600 | 0.02 | 0.09 |
| 10500–5 lakh | 450 | 0.33 | 0.64 | 0.596 | 0.359 | 0.03 | 0.12 |
| Total | 1304 | | | | | | |
| Avg. | | 0.26 | | 0.42 | | 0.02 | |

household, 55.59% with 3.10–6 per household, 24.76% with 6.05–9 per household, 4.91% with 9.05–12 per household and 2.38% have > 12 adult equivalents per household.

The data shows a reduced average per capita fuel consumption with increase in adult equivalents per household. Table 24 shows that the average fuel wood requirement per person per day for cooking ranges from 2.35 kg (< 3 adults) to 1.42 kg (> 12 adults). Similarly, Table 25 illustrates that the average fuel wood requirement for water heating ranges from 1.99 (< 3 adults), 1.33 (3.1–6 adults) to 0.73 (> 12 adults) kg/person/day.

Regression analyses of per capita fuel consumption (PCFC) in kgs/person/day and number of persons per household (NOP) show that the PCFC is linearly correlated with NOP, i.e.

$$\text{PCFC} = 2.341 - 0.122\ (\text{NOP}),$$

with a correlation coefficient of 0.36 and standard error of $Y$ estimate = 0.923.

This interesting reduction in fuel wood consumption with an increase in number of persons per household is due to the co-efficiencies of cooking and water heating that result from increased scales of the same. Therefore, proper design of the stoves and size of vessels being used in relation to the number of persons per household are essential parameters in bringing down fuel wood consumption.

### 7.10. Effect of educational level of household members on energy consumption

Qualitative data of the educational level of household members who are directly involved in domestic activity is quantified as 0 (illiterate), 1 (primary education), 2 (up to 10th standard) and 3 (college education). It is noticed that educated users are more receptive to adopting energy efficient devices and are also efficient in utilising energy, even in traditional devices.

Table 23
Kerosene and electricity for lighting in various household income categories

| | | Lighting energy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Kerosene (l/person/month) | | | | | | |
| | | Electricity (kWh/person/month) | | Electricity (Rs./capita/month) | | Summer | | Winter | | Monsoon | | Average |
| Income | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. |
| < 3600 | 215 | 1.34 | 1.86 | 1.23 | 2.22 | 0.83 | 0.51 | 0.89 | 0.48 | 0.89 | 0.49 | 0.87 |
| 4000–10000 | 639 | 2.21 | 2.48 | 2.48 | 3.75 | 0.73 | 0.44 | 0.81 | 0.45 | 0.80 | 0.47 | 0.78 |
| 10500–5 lakh | 450 | 4.79 | 3.85 | 5.84 | 6.29 | 0.76 | 0.61 | 0.79 | 0.61 | 0.81 | 0.61 | 0.79 |
| Total | 1304 | | | | | | | | | | | |
| Avg. | | 2.78 | | 3.18 | | 0.77 | | 0.83 | | 0.83 | | 0.81 |

Table 24
Cooking fuel wood consumption in various categories of number of adult equivalent/household

| | | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Number of persons per household | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 0.80–3.00 | 161 | 2.25 | 2.66 | 2.30 | 2.86 | 2.51 | 4.02 | 2.35 | 3.18 |
| 3.10–6.00 | 725 | 2.10 | 1.20 | 2.11 | 1.25 | 2.24 | 1.54 | 2.15 | 1.33 |
| 6.05–9.00 | 323 | 1.59 | 0.72 | 1.67 | 0.79 | 1.75 | 0.80 | 1.67 | 0.77 |
| 9.05–12.00 | 64 | 1.57 | 1.59 | 1.59 | 0.72 | 1.70 | 0.97 | 1.62 | 1.09 |
| > 12.00 | 31 | 1.40 | 0.65 | 1.40 | 0.68 | 1.46 | 0.74 | 1.42 | 0.69 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.78 | | 1.81 | | 1.93 | | 1.84 | |

Regression analyses performed between the variables PCFC and level of education of members (EDU), show that these two are linearly correlated as

$$\mathrm{PCFC} = 3.21 - 1.021\ (\mathrm{EDU}),$$

with a correlation coefficient of 0.845 and standard error of $Y$ estimate 0.506 ($p < 0.001$).

This is mainly due to awareness associated with the level of education. This result clearly demonstrates that increase in literacy level among the rural population would directly benefit in the form of less energy consumption.

Table 25
Water heating fuel wood consumption in various categories of number of adult equivalent/household

| | | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Number of persons per household | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 0.80–3.00 | 161 | 1.82 | 0.83 | 2.06 | 0.96 | 2.10 | 1.00 | 1.99 | 0.07 |
| 3.10–6.00 | 725 | 1.25 | 0.49 | 1.33 | 0.56 | 1.42 | 0.60 | 1.33 | 0.04 |
| 6.05–9.00 | 323 | 1.00 | 0.44 | 1.01 | 0.43 | 1.07 | 0.49 | 1.03 | 0.03 |
| 9.05–12.00 | 64 | 0.91 | 0.38 | 0.92 | 0.36 | 0.96 | 0.38 | 0.93 | 0.01 |
| > 12 | 31 | 0.70 | 0.33 | 0.72 | 0.33 | 0.76 | 0.34 | 0.73 | 0.00 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.14 | | 1.21 | | 1.26 | | 1.20 | |

### *7.11. Energy consumption based on type of devices — traditional vs energy efficient devices (ASTRA stoves)*

Only 2.07% (27 households) and 1.68% (22 households) of the 1304 surveyed households use energy efficient stoves for cooking and water heating respectively. Per capita fuel consumption for cooking, listed in Table 26, shows that it is reduced from 2.14 (traditional stoves) to 0.97 (ASTRA stoves) kg/person/day. Hence, there is a reduction of 54.67% in the daily consumption of fuel wood for cooking. Table 27 lists fuel consumption for water heating, which shows a saving of 22.30% by switching to ASTRA stoves (1.01 kg/person/day) from traditional stoves (1.30 kg/person/day).

## 8. Energy consumption for other purposes, in the domestic sector

In the following section, we discuss energy requirements for other purposes, such as parboiling, jaggery making etc., in the domestic sector.

### *8.1. Fuel consumption for space heating*

It is seen that 65 out of 744 households in zone 1 and 80 out of 301 households in zone 2 use fuel for space heating during the season at a rate of 0.15 kg/person/day, while, 80% of the households (207 out of 259) in zone 3, due to incessant rain, use fuelwood for space heating and drying of cloth at the rate of 1.11 kg/person/day.

### *8.2. Fuel consumption for areca boiling (red variety preparation)*

Specific fuel consumption (SFC), computed based on data from 12 households, ranges from 1.97 to 2.03 (this means the fuel wood required for a quintal of areca processing is 1.97 to 2.03 quintals).

Table 26
Cooking fuel wood consumption based on type of devices

| | | Cooking fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Cooking devices | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Astra | 27 | 0.89 | 0.68 | 0.91 | 0.60 | 1.11 | 0.79 | 0.97 | 0.69 |
| Traditional | 1277 | 2.06 | 1.42 | 2.09 | 1.49 | 2.26 | 1.97 | 2.14 | 1.63 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.47 | | 1.50 | | 1.68 | | 1.55 | |

Table 27
Fuel wood consumption for water heating based on type of devices

| | | Water heating fuel wood (kg/person/day) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer | | Winter | | Monsoon | | Average | |
| Bath stoves | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Astra | 22 | 0.89 | 0.43 | 1.02 | 0.50 | 1.12 | 0.66 | 1.01 | 0.53 |
| Traditional | 1282 | 1.23 | 0.59 | 1.28 | 0.68 | 1.38 | 0.70 | 1.30 | 0.66 |
| Total | 1304 | | | | | | | | |
| Avg. | | 1.06 | | 1.15 | | 1.25 | | 1.15 | |

### 8.3. Jaggery manufacture

The fuel wood required in traditional stoves to convert 300 litres of sugar cane juice into about 40 litres of viscous jaggery is 195–220 kg, while in the ASTRA stove (jaggery stove designed by ASTRA), it is 160–175 kg, showing a 25–30% reduction in fuel wood consumption. SFC computed based on data from 8 households (2 in zone 2 and 6 in zone 3) ranges from 4.88 to 5.52.

### 8.4. Parboiling

Boiled rice is used in most of the households in Kumta taluk. 68% of the surveyed households use boiled rice regularly (mainly in zones 1 and 2). The fuel type used for this purpose ranges from rice husk, fuel wood to coconut residues. The SFC computed ranges from 0.70 to 0.89, which means, for manufacturing 1 quintal of rice, the fuel wood equivalent required is about 0.7–0.89 quintals.

## 9. Energy consumption pattern in Kumta town

The Kumta town muncipality has divided the town into 5 blocks. Approximately 260 households were selected from each block, covering all sections of the society.

Data of the 1307 surveyed households was categorised based on annual income. 280 households belong to the low income category (< Rs. 3,600 per year), 214 to the middle class category (Rs. 3600–10,000), 800 to the Rs. 10,000–100,000 category and 13 households more than Rs. 100,000 income category.

Out of 280 households in low income category, 266 (95%) completely depend on fuel wood for cooking, 13 use kerosene stoves for boiling milk, preparation of tea etc. and 1 household (landless) uses LPG in addition to fuel wood.

In the middle income category of 214 households, 199 (92.2%) completely depend on fuel

Table 28
Energy consumption for cooking and water heating based on household income in Kumta Town

| | | Cooking Energy | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel wood (kg/person/day) | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Bath stove (kg/person/day) | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 280 | 1.80 | 1.09 | 0.17 | 1.48 | 0.00 | 0.00 | 0.04 | 0.02 | 1.23 | 1.65 |
| 3600–10000 | 214 | 1.59 | 0.92 | 0.24 | 1.54 | 0.00 | 0.00 | 0.00 | 0.00 | 1.17 | 0.85 |
| 10000–1 lakh | 800 | 1.85 | 0.92 | 0.18 | 1.91 | 0.11 | 2.23 | 0.10 | 0.03 | 1.04 | 1.15 |
| > 1 lakh | 13 | 2.03 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.08 | 0.82 | 1.03 |
| Total | 1307 | | | | | | | | | | |
| Avg. | | 1.82 | | 0.15 | | 0.03 | | 0.09 | | 1.07 | |

wood and 3 depend on kerosene stoves, while the remaining 12 households use both kerosene stoves and fuel wood for cooking.

In the Rs. 10,000–100,000 income category, about 62% (496 out of 800 households) use only fuel wood, 18% (144) use kerosene and fuel wood, 16% (128) use biogas, fuel wood and kerosene and 4% (32) use LPG, fuel wood and kerosene for cooking. In more than Rs. 100,000 income category of 13 households, 9 (69.23%) use only fuel wood, while the remaining 4 (30.77%) use both LPG and fuel wood.

Fuel consumption for cooking and water heating in these categories is listed in Table 28. Fuel wood consumption for cooking ranges from 1.59 (Rs. 3600–10,000 category) to 2.03 (> Rs. 100,000 category) kgs/person/day, while for water heating, it ranges from 0.82 (> Rs. 100,000 category) to 1.23 (low income category) kg/person/day. It is worth noting that the middle income category depends mainly on fuel wood supplied by the Government Fuel Depot (40–55%) and Private Suppliers, while the low income category prefers to collect it from forests (in the vicinity of 5–10 km). This is mainly done by women and children. Normally, people from many households collectively go to the forest (Mirjan, Kattalekan, Halkar, etc.) at about 5 a.m. and return at about 1 p.m., each individual carrying an average of 20–26 kg (head load) of fuel wood.

Kerosene and electricity usage for lighting in Kumta town is listed in Table 29. It is seen that kerosene usage is more or less the same in the first three income categories, while in the annual income > Rs. 100,000 category, consumption is very much less. Electricity consumption analyses show the dependence of higher income categories for lighting compared to the first two categories. It ranges from 3.13 (Rs. 3,600–10,000), 5.96 (Rs. 10,000–100,000) to 14.47 (> Rs. 100,000 category) kWh/person/month.

Table 30 lists the results of the analyses based on the number of persons per household. Fuel wood consumption for cooking ranges from 2.14 (< 3 adults) to 0.92 (> 12 adults) kg/person/day, while for water heating, it ranges from 1.31 to 0.88 kg/person/day. This confirms the

Table 29
Energy consumption for lighting based on household income in Kumta Town

| | | | | Lighting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Space heating (kg/person/season) | | Kerosene (l/person/month) | | Electricity (kWh/person/month) | | Electricity cost (Rs./capita/month) | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 280 | 0.00 | 0.00 | 0.34 | 0.23 | 3.58 | 4.98 | 6.59 | 11.69 |
| 3600–10000 | 214 | 0.00 | 0.00 | 0.45 | 0.68 | 3.13 | 3.37 | 4.70 | 6.74 |
| 10000–1 lakh | 800 | 0.00 | 0.00 | 0.34 | 0.56 | 5.96 | 6.76 | 11.23 | 15.64 |
| > 1 lakh | 13 | 0.00 | 0.00 | 0.02 | 0.10 | 14.47 | 8.89 | 42.89 | 30.48 |
| Total | 1307 | | | | | | | | |
| Avg. | | 0.00 | | 0.29 | | 6.79 | | 16.35 | |

Table 30
Fuel consumption for cooking and water heating based on number of persons/household

| | | Cooking energy | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel wood (kg/person/day) | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Bath stove (kg/person/day) | |
| No. of persons/household | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 0.8–3.0 | 368 | 2.14 | 0.87 | 0.21 | 2.49 | 0.00 | 0.00 | 0.00 | 0.04 | 1.31 | 1.38 |
| 3.10–6 | 697 | 1.79 | 1.00 | 0.19 | 1.49 | 0.13 | 2.39 | 0.12 | 0.02 | 1.10 | 1.27 |
| 6.05–9 | 186 | 1.30 | 0.73 | 0.24 | 0.77 | 0.00 | 0.00 | 0.15 | 0.03 | 1.07 | 0.66 |
| 9–12 | 41 | 1.08 | 0.59 | 0.22 | 1.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.92 | 0.73 |
| > 12 | 15 | 0.92 | 0.86 | 0.35 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.88 | 0.91 |
| Total | 1307 | | | | | | | | | | |
| Avg. | | 1.45 | | 0.24 | | 0.03 | | 0.05 | | 1.06 | |

Table 31
Communitywise fuel consumption for cooking and water heating

| Community | No. of samples | Cooking energy | | | | | | | | Bath stove (kg/person/day) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel wood (kg/person/day) | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | | |
| | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| Uppar | 27 | 1.17 | 0.64 | 0.05 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.78 | 0.54 |
| Shetty | 24 | 1.64 | 0.96 | 0.18 | 0.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.90 | 0.60 |
| Patgar | 110 | 1.99 | 1.10 | 0.17 | 0.63 | 0.00 | 0.00 | 0.00 | 0.00 | 1.12 | 1.57 |
| Others | 91 | 1.53 | 0.68 | 0.24 | 2.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.89 | 1.45 |
| Naik | 240 | 1.61 | 0.94 | 0.21 | 1.66 | 0.00 | 0.00 | 0.01 | 0.05 | 0.96 | 0.92 |
| Muslim | 73 | 2.16 | 1.20 | 0.24 | 1.98 | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 | 1.43 |
| Havyak Brahmin | 190 | 2.08 | 1.17 | 0.32 | 2.16 | 0.23 | 0.31 | 0.00 | 0.00 | 1.27 | 1.55 |
| Gunaga | 9 | 2.02 | 1.01 | 0.31 | 3.70 | 0.00 | 0.00 | 0.00 | 0.00 | 2.04 | 2.08 |
| GS Brahmin | 162 | 1.85 | 0.76 | 0.19 | 2.10 | 0.00 | 0.00 | 0.00 | 0.00 | 1.17 | 1.27 |
| Gouda | 251 | 1.80 | 0.86 | 0.10 | 1.30 | 0.00 | 0.00 | 0.00 | 0.03 | 1.09 | 1.06 |
| Deshbandari | 4 | 1.58 | 0.49 | 0.14 | 2.23 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 | 0.33 |
| Christian | 52 | 1.54 | 0.77 | 0.23 | 1.00 | 0.90 | 6.41 | 0.01 | 0.05 | 1.02 | 0.81 |
| Bhandari | 31 | 1.47 | 0.66 | 0.21 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.96 | 0.69 |
| Ambiga | 19 | 1.62 | 0.95 | 0.05 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 1.08 |
| Achari | 24 | 1.88 | 0.74 | 0.15 | 1.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.99 | 0.75 |
| Total | 1307 | | | | | | | | | | |
| Avg. | | 1.73 | | 0.19 | | 0.08 | | 0.00 | | 1.13 | |

earlier result (Kumta rural area) that per capita fuel consumption reduces with an increase in the number of persons per household.

Table 31 lists communitywise fuel consumption for cooking and water heating. This illustrates the intra-community variation in fuel consumption in kg/person/day. Havyak Brahmin (2.08 — cooking, 1.27 — water heating), Muslim (2.16 — cooking, 1.50 — water heating) and Gunaga (2.02 — cooking, 2.04 — water heating) seem to be the energy intensive communities in Kumta town. The Uppar community has the minimum per capita consumption (1.17 — cooking, 0.78 — water heating).

Communitywise monthly electricity consumption (Table 32) shows that communities like Havyak Brahmin (HB), Shetty (SH), Gouda Saraswath Brahmin (GSB) etc. are some of the electricity intensive communities in Kumta town with 7.09, 6.81 and 6.07 kWh/person, respectively.

## 10. Fuel wood consumption pattern in Mundgod taluk

The Mundgod taluk with plain terrain, differs distinctly from the coastal and hilly taluks. In order to see the level of consumption, analysis of data collected from 190 randomly selected households was performed. Energy consumption for domestic purposes (cooking, water heating, space heating and lighting), based on annual income and number of persons per

Table 32
Communitywise monthly per capita electricity consumption

| | | Electricity (kWh/person/month) | | Electricity (Rs/capita/month) | |
|---|---|---|---|---|---|
| Community | No. of samples | Avg. | SD | Avg. | SD |
| Uppar | 27 | 1.06 | 1.96 | 1.26 | 2.72 |
| Shetty | 24 | 6.81 | 4.07 | 12.35 | 14.13 |
| Patgar | 110 | 5.70 | 6.26 | 5.57 | 18.90 |
| Others | 91 | 3.42 | 3.25 | 6.60 | 8.85 |
| Naik | 240 | 4.61 | 5.02 | 6.87 | 10.32 |
| Muslim | 73 | 3.45 | 4.39 | 8.02 | 14.56 |
| HB | 190 | 7.09 | 7.65 | 12.79 | 17.79 |
| Gunaga | 9 | 2.46 | 1.74 | 2.77 | 1.90 |
| GSB | 162 | 6.07 | 8.36 | 11.26 | 16.57 |
| Gouda | 251 | 4.80 | 6.40 | 8.99 | 15.39 |
| Deshbhandari | 4 | 1.36 | 1.36 | 2.90 | 2.91 |
| Christian | 52 | 5.57 | 4.15 | 10.33 | 13.00 |
| Bhandari | 31 | 4.30 | 3.81 | 5.74 | 5.41 |
| Ambiga | 19 | 2.02 | 3.33 | 1.52 | 2.97 |
| Achari | 24 | 4.91 | 3.78 | 7.24 | 4.95 |
| Total | 1307 | | | | |
| Avg. | | 4.24 | | 6.95 | |

Table 33
Energy consumption for cooking and water heating in Mundgod

| | | Cooking energy | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel wood (kg/person/day) | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Bath stove (kg/person/day) | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 112 | 1.74 | 1.22 | 0.35 | 0.60 | 0.43 | 4.55 | 0.01 | 0.08 | 1.29 | 1.28 |
| 4000–10,000 | 40 | 1.37 | 1.76 | 0.48 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1.27 | 1.46 |
| > 10,500 | 38 | 1.84 | 1.86 | 0.59 | 0.56 | 0.00 | 0.00 | 0.00 | 0.00 | 1.36 | 1.49 |
| Total | 190 | | | | | | | | | | |
| Avg. | | 1.65 | | 0.47 | | 0.14 | | 0.00 | | 1.31 | |

Table 34
Energy consumption for space heating and lighting (based on household income) in Mundgod taluk

| | | | | Lighting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Space heating fuel wood (kg/person/season) | | Kerosene (l/person/month) | | Electricity (kWh/person/month) | | Electricity cost (Rs./capita/month) | |
| Income (Rs.) | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| < 3600 | 112 | 0.00 | 0.00 | 0.54 | 0.32 | 3.68 | 3.97 | 11.72 | 22.22 |
| 4000–10,000 | 40 | 0.00 | 0.00 | 0.52 | 0.22 | 1.30 | 2.21 | 1.77 | 2.98 |
| > 10,500 | 38 | 0.00 | 0.00 | 0.34 | 0.18 | 6.01 | 5.91 | 10.16 | 18.01 |
| Total | 190 | | | | | | | | |
| Avg. | | 0.00 | | 0.47 | | 3.66 | | 7.88 | |

Table 35
Energy consumption for cooking and water heating in Mundgod (based on number of persons/household)

| | | Cooking energy | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel wood (kg/person/day) | | Kerosene (l/person/month) | | Biogas ($m^3$/person/day) | | LPG (kg/person/month) | | Bath stove (kg/person/day) | |
| No. of persons/household | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 0.8–3.0 | 62 | 1.92 | 1.07 | 0.69 | 0.18 | 0.00 | 0.00 | 0.01 | 0.11 | 1.41 | 1.65 |
| 3.0–6.0 | 107 | 1.69 | 1.22 | 0.78 | 0.60 | 0.45 | 4.63 | 0.00 | 0.00 | 1.59 | 1.23 |
| 6.0–9.0 | 18 | 1.82 | 1.61 | 0.42 | 0.57 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | 1.13 |
| 9.0–12 | 3 | 1.24 | 1.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.22 | 1.19 |
| Total | 190 | | | | | | | | | | |
| Avg. | | 1.67 | | 0.47 | | 0.11 | | 0.00 | | 1.37 | |

Table 36
Energy consumption for space heating and lighting (in Mundgod)

| | | Space heating fuel wood (kg/person/season) | | Lighting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kerosene (l/person/month) | | Electricity (kWh/person/month) | | Electricity cost (Rs./capita/month) | |
| No. of persons/household | No. of samples | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| 0.8–3.0 | 62 | 0.00 | 0.00 | 0.56 | 0.34 | 5.38 | 6.47 | 13.20 | 29.26 |
| 3.0–6.0 | 107 | 0.00 | 0.00 | 0.34 | 0.12 | 3.10 | 2.94 | 8.13 | 12.75 |
| 6.0–9.0 | 18 | 0.00 | 0.00 | 0.45 | 0.22 | 3.13 | 1.64 | 5.37 | 5.22 |
| 9.0–12 | 3 | 0.00 | 0.00 | 0.32 | 0.10 | 1.28 | 0.93 | 3.47 | 0.46 |
| Total | 190 | | | | | | | | |
| Avg. | | 0.00 | | 0.42 | | 3.22 | | 7.54 | |

household, was determined and is listed in Tables 33 and 34 and Tables 35 and 36, respectively.

Table 33 shows that the average fuel requirement for cooking is about 1.65 kg/person/day. It ranges from 1.37 kg (middle income) to 1.84 kg (for income > Rs. 10,500/year). The average per capita fuel wood consumption for water heating is 1.31 kg.

Table 34 lists per capita monthly electricity and kerosene consumption for lighting, which shows increased electricity and decreased kerosene consumption with an increase in household income.

Table 35 confirms our earlier conclusion (Kumta taluk), that per capita fuel wood consumption decreases with an increase in the number of persons per household. Fuel wood requirement for cooking ranges from 1.92 (0.80–3.0 person/household) to 1.24 (9.0–12 person/household), while for water heating it ranges from 1.41 to 1.22 kg/person/day.

Table 36 listing the energy requirement for lighting, shows the variation from 5.38 (0.8–3.0 person/household) to 1.28 (9.0–12 person/household) kWh/person/month.

## 11. Fuelwood consumption for cooking and water heating in Sirsi taluk

The average per capita fuel consumption in 202 sample households located in the villages of Sonda, Mogadde, Bhairumbhe, Neernalli and Kalave for cooking is 2.22 (avg) $\pm$ 0.92(SD), while for water heating, it is $1.72 \pm 0.68$ kg/person/day.

End use efficiency experiments conducted in households located in the Sirsimakki–Mundgesara catchment show consumption in traditional stoves as $1.92 \pm 1.02$ and improved stoves as $1.1 \pm 0.78$ kg/person/day, showing a saving of about 42% in fuel consumption in the improved cook stoves (ASTRA design).

The fuel requirement for water heating is mainly met by residues of coconut and areca plantations and partly by fuel wood. The average fuel consumption in traditional stoves is $1.68 \pm 0.80$ and improved bath stoves $1.36 \pm 0.63$ kg/person/day, showing a saving of 19–24% in the improved design (ASTRA).

Table 37
Regionwise fuel requirement for cooking and water heating (based on average values of per capita fuel consumption)

| | Region | Cooking average (kg/person/day) | Water heating average (kg/person/day) |
|---|---|---|---|
| 1 | Mundgod | 1.65 | 1.31 |
| 2 | Kumta Town | 1.82 | 1.07 |
| 3 | Sirsi (semi-urban) | 1.92 | 1.68 |
| 4 | Kumta Coast | 2.01 | 1.17 |
| 5 | Kumta Interior | 2.19 | 1.35 |
| 6 | Sirsi Hilly | 2.22 | 1.72 |
| 7 | Kumta Hilly | 2.32 | 1.63 |
| | Avg. | 2.02 | 1.42 |

## 12. Regionwise comparison

Table 37 is a compilation of the surveys conducted in various taluks (regions) of the Uttara Kannada district which shows the variation in fuelwood consumption from 1.65 (Mundgod) to 2.32 (Kumta hilly) for cooking in kg/person/day. Fig. 3 depicts the variation in fuel wood consumption due to geographic factors. It illustrates that households located in hilly regions consume 40.6% more fuelwood than those in the plains.

Fig. 4 illustrates the regionwise variation in fuel consumption for water heating, which ranges from 1.07 (Kumta town) to 1.72 (Sirsi-hilly region). In most of the surveyed households, 65–75% of the fuel requirement is met by bioresidues, such as coconut husk, coconut leaves, areca residues etc. Based on these calculations, the overall average fuel wood consumption for cooking is about 2.02 and water heating about 1.42 kg/person/day.

These surveys have revealed that the levels of energy use and mix of energy sources depend on the following factors:

1. geographic and climatic factors (space heating, drying needs, altitude, seasonal variation in cooking energy requirement),
2. culture and traditions (diet, cooking habits etc.),
3. household income (urban),
4. household ownership of assets such as land, cattle etc. (rural),
5. household size (number of persons per household),

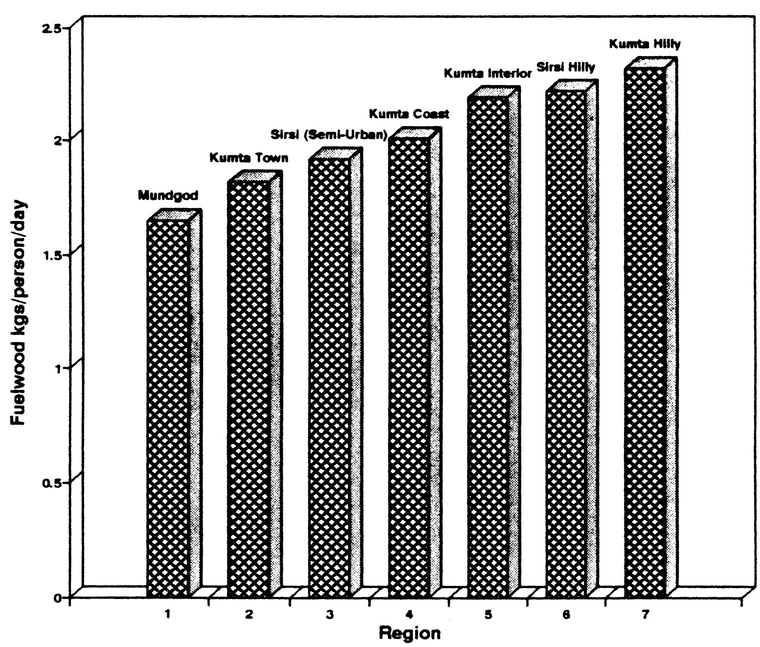


Fig. 3. Fuel wood consumption (cooking) regionwise comparison.

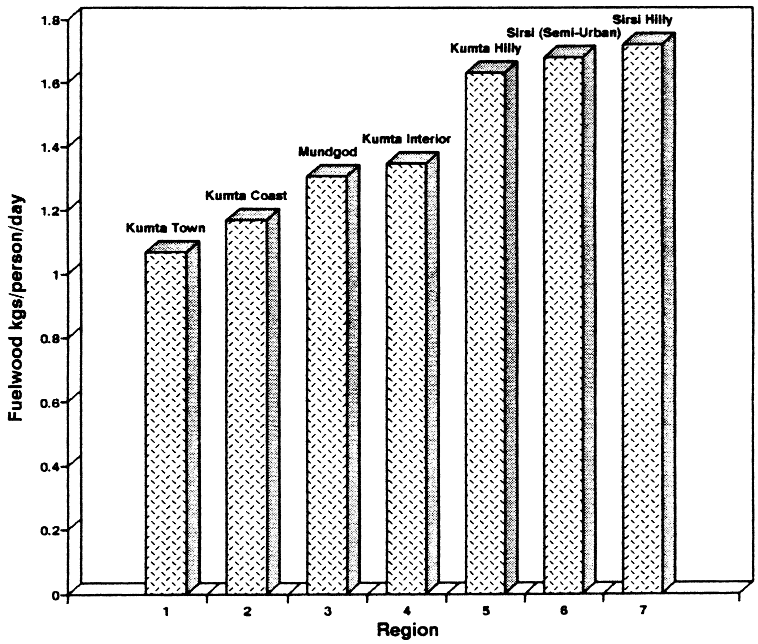


Fig. 4. Fuel for water heating regionwise comparison.

6. educational level of household members (educated women are found to be more receptive to alternatives, such as fuel efficient stoves, biogas etc.), and
7. end use technologies (thermal efficiency of cooking and water heating devices).

## 13. Total demand for fuel in Uttara Kannada District

Based on fuel consumption norms determined for various regions in these surveys, the talukwise fuel demand for cooking and water heating is computed and listed in Table 38. Currently, about 60% (approx.) of the fuel for water heating is met by agricultural residues. With this assumption, the fuel wood required for domestic cooking and water heating is 1,202,615.64 tonnes, and the agriculture residues is about 367,861.44 tonnes (fuel wood equivalent). Thus, the total fuel wood required for the domestic sector is about 1,570,477.07 tonnes.

Because of incessant rain in this region, fuel wood (normally logs) is used to keep the place warm and dry clothes. This requirement in the coastal and hilly regions is about 0.15 and 1.11 kg/person/day, respectively, amounting to 53,772.5 tonnes during monsoon.

Table 39 lists the talukwise kerosene demand for cooking and lighting and electricity for domestic purpose (excludes irrigation). The kerosene demand of the district for lighting and cooking is about 12.54 and 3.32 million litres, respectively. The LPG required is about 226.40 tonnes (or 15613 cylinders) per year. The electricity demand in the domestic sector (lighting and All Electric homes) is about 32.65 million kWh per year. Table 40 lists, activitywise, the

Table 38
Talukwise fuel wood consumption for cooking and water heating

| Sl.No. | Taluk | Area (ha) | Population 1991 | FW demand for cooking (tonne) | FW demand for bathing (tonne) | FW (cook + 100% bath) total | Fuel wood total cook + 40% bath | Agricultural residues | Space heating |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ankola | 91,870.00 | 91,310 | 67,100.68 | 38,993.94 | 106,094.61 | 82,698.25 | 23,396.36 | 1232.68 |
| 2 | Bhatkal | 35,731.96 | 129,017 | 94,810.29 | 55,096.71 | 149,907.00 | 116,848.98 | 33,058.03 | 1741.73 |
| 3 | Haliyal | 86,489.33 | 94,363 | 75,314.26 | 46,497.37 | 121,811.62 | 93,913.20 | 27,898.42 | 1273.90 |
| 4 | Honavar | 77,546.13 | 145,842 | 107,174.42 | 62,281.83 | 169,456.25 | 132,087.15 | 37,369.10 | 1968.86 |
| 5 | Karwar | 73,210.00 | 142,845 | 104,972.03 | 61,001.96 | 165,973.99 | 129,372.81 | 36,601.17 | 1928.40 |
| 6 | Kumta | 58,486.81 | 134,144 | 98,577.95 | 57,286.20 | 155,864.15 | 121,492.43 | 34,371.72 | 1810.94 |
| 7 | Mundgod | 66,890.00 | 77,939 | 46,938.76 | 37,266.53 | 84,205.30 | 61,845.38 | 22,359.92 | 1052.17 |
| 8 | Siddapur | 85,930.00 | 94,202 | 79,770.25 | 56,045.48 | 135,815.73 | 102,188.45 | 33,627.29 | 9410.78 |
| 9 | Sirsi | 133,342.62 | 152,935 | 129,505.36 | 90,988.68 | 220,494.04 | 165,900.83 | 54,593.21 | 15,278.21 |
| 10 | Supa | 189,514.23 | 99,519 | 84,272.69 | 59,208.83 | 143,481.52 | 107,956.22 | 35,525.30 | 9941.95 |
| 11 | Yellapur | 130,110.00 | 81,410 | 68,937.99 | 48,434.88 | 117,372.87 | 88,311.94 | 29,060.93 | 8132.86 |
| | District | 1,029,121.08 | 1,243,526 | 957,374.68 | 613,102.39 | 1,570,477.07 | 1,202,615.64 | 367,861.44 | 53772.48 |
| | Computation from district average | | | 986,447.72493 | 627,877.00283 | 1,614,324.73 | 1,237,598.53 | | |

Table 39
Talukwise energy consumption for cooking and lighting

| Sl. No. | Taluk | Area (ha) | Population 1991 | Kerosene cooking × 1000 litres | LPG cooking × 1000 kg | Kerosene lighting × 1000 litres | Electricity lighting × 1000 kWh | Electricity lighting × 1000 Rs. |
|---|---|---|---|---|---|---|---|---|
| 1 | Ankola | 91,870.00 | 91,310 | 372.54 | 21.91 | 818.14 | 2739.30 | 3078.97 |
| 2 | Bhatkal | 35,731.96 | 129,017 | 526.39 | 30.96 | 1155.99 | 3870.51 | 4350.45 |
| 3 | Haliyal | 86,489.33 | 94,363 | 237.79 | 11.32 | 936.08 | 2955.45 | 3012.07 |
| 4 | Honavar | 77,546.13 | 145,842 | 595.04 | 35.00 | 1306.74 | 4375.26 | 4917.79 |
| 5 | Karwar | 73,210.00 | 142,845 | 582.81 | 34.28 | 1279.89 | 4285.35 | 4816.73 |
| 6 | Kumta | 58,486.81 | 134,144 | 547.31 | 32.19 | 1201.93 | 4024.32 | 4523.34 |
| 7 | Mundgod | 66,890.00 | 77,939 | 196.41 | 9.35 | 773.15 | 2441.05 | 2487.81 |
| 8 | Siddapur | 85,930.00 | 94,202 | 56.52 | 11.30 | 1115.35 | 1752.16 | 2181.72 |
| 9 | Sirsi | 13,3342.62 | 152,935 | 91.76 | 18.35 | 1810.75 | 2844.59 | 3541.97 |
| 10 | Supa | 189,514.23 | 99,519 | 59.71 | 11.94 | 1178.30 | 1851.05 | 2304.86 |
| 11 | Yellapur | 130,110.00 | 81,410 | 48.85 | 9.77 | 963.89 | 1514.23 | 1885.46 |
| | District | 1,029,121.08 | 1,243,526 | 3315.13 | 226.40 | 12,540.23 | 32,653.27 | 37,101.18 |
| | Computation from district average | | | 2984.46 | 149.22 | 12,733.71 | 33,127.53 | 36,808.37 |

Table 40
Total requirement of fuel wood for Uttara Kannada District

| Activity | Fuel wood requirement |
|---|---|
| Cooking and water heating | 1,570,477.07 |
| Space heating | 53,772.48 |
| Jaggery manufacture | 41,316.65 |
| Areca processing | 1399.88 |
| Parboiling | 1732.15 |
| Total (tonnes) | 1,668,698.23 |

total annual requirement of fuel wood. The total fuel wood equivalent required for the domestic sector is about 1,570,477.1 tonnes and for space heating about 53,772.5 tonnes.

The Uttara Kannada District produces about 149,698 tonnes of sugar cane per year (1992–93 and 1993–94 production), out of which jaggery is prepared for domestic purposes. The fuel required for this is about 41,316.65 tonnes.

Areca is one of the major horticultural crops in the Uttara Kannada district. Boiling of Areca (to manufacture the red variety for day to day use) is another fuel intensive operation performed here, requiring about 1399.88 tonnes of fuel wood per year.

Boiled rice is commonly used in coastal taluks. Fuel wood and rice husks are used for parboiling. The quantity of fuel wood required is about 1732.15 tonnes.

Thus, the total fuel wood demand in the domestic sector of Uttara Kannada District (Table 40) is about 1,668,698 tonnes.

## 14. Conclusions

The average consumption of fuel wood for cooking and water heating varies considerably among agro-climatic zones (in terms of quantity of fuel used). Significant seasonal variation in consumption of fuel is noticed in all zones during monsoon among various communities. The amount of cooking fuel used per person does not vary substantially with household income in both rural and urban areas. Higher income groups are also dependent on fuel wood significantly.

In rural areas, scarce income combined with freely available biomass fuels lead people to continue to depend on biomass fuel. When firewood is scarce, residents depend on crop residues and dung. Poor distribution of fuels, such as kerosene in rural areas and LPG in towns, is an impeding factor in switching to modern fuels.

Fuel wood consumption analysis illustrates the seasonal and regional variation. Average consumption ranges from $2.01 \pm 1.49$ (coastal) to $2.32 \pm 2.09$ (hilly) kg/person/day. Seasonwise, the fuel wood requirement for coastal and hilly zones ranges from 1.98 and 2.22 (summer) to 2.11 and 2.51 (monsoon) kg/person/day, respectively.

The data also reveals variations in fuel wood requirement for water heating (for bath and washing), which ranges from $1.17 \pm 0.02$ (coast) to $1.63 \pm 0.05$ (hilly) kg/person/day. Seasonal variation is also evident for coastal and hilly zones from 1.12 and 1.53 (summer) to 1.22 and 1.73 (monsoon) kg/person/day, respectively.

The overall picture of other sources of energy for domestic purposes shows that kerosene is used for both cooking and lighting in the coastal zone. Kerosene for cooking ranges from 0.05 (hilly) to 0.34 (coast) l/person/month. Survey results reveal that the availability of bioresources in the hilly region is the main reason for less consumption of kerosene for cooking compared to the coastal region.

Kerosene for lighting ranges from 0.75 (coast) to 0.99 (hilly) l/person/month. The hilly zone is more dependent on kerosene for lighting due to the non-availability of electricity, as households are spatially distributed, hindering electrification. This is apart from the erratic electricity supply during all seasons (more in monsoon).

2.68% of the sample accounted for the landless category, while families owning 0–0.5, 0.5–0.75, 0.75–1.25, 1.25–1.75, 1.75–2 and > 2 ha of land accounted for 24.76, 32.13, 17.48, 6.53, 5.23 and 11.19%, respectively. The daily energy consumption computed for each category shows a variation from 1.83 (landless) to 2.31 ( > 2 ha) for cooking and 1.23 (landless) to 1.60 ( > 2 ha) kg/person/day for water heating. Most of the households in all these categories still use firewood for cooking and a kerosene stove for boiling milk, tea preparation etc.

Out of 1304 households only 18 use biogas for cooking supplemented by a kerosene stove, (6 belong to > 2 ha, 4 to 1.75–2 ha and 8 distributed, in the remaining 5 categories). Fuel wood stoves are used only on special occasions. Biogas for cooking ranges from 0.276 (landless) to 0.775 ( > 2 ha) $m^3$/person/day.

Electricity consumption increased with the increase in landholding, ranging from 1.99 (landless), 2.14 (0–0.5 ha) to 3.59 ( > 2 ha) kWh/person/day. Kerosene usage for lighting decreased with the increase in landholding, varying from 0.87 (landless), 0.86 (0–0.5 ha) to 0.75 ( > 2 ha) l/person/month.

Based on fuel consumption norms (regionwise, seasonwise and end usewise) obtained from detailed household surveys, it is estimated that (a) fuel wood required in the domestic sector (for cooking, water heating, space heating, jaggery making and parboiling) of the Uttara Kannada District works out to 1,668,698.25 tonnes/year, (b) electricity demand in the domestic sector (excluding irrigation) is about 32.65 million kWh/year and (c) kerosene demand for cooking and lighting is about 15.86 million litres per year.

Fuel efficiency studies reveal that there is scope for saving 27.45 to 42% fuel wood by switching to improved stoves. The specific consumption of biomass fuels used in the domestic sector in most of the villages of Kumta taluk is quite high. Considering the low efficiency of the devices at present, there is scope for improvement. In our sample of 1304 households, only 22 use improved stoves. Lack of knowledge, proper training and service backup facilities are the main contributing factors for not adopting efficient devices. By switching to energy efficient devices, such as ASTRA stoves, the saving of fuelwood in the domestic sector would be 450,548 to 700,853 tonnes per year.

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