PATTERNS OF DOMESTIC ENERGY CONSUMPTION IN RURAL KERALA: A STUDY OF SELECTED VILLAGES

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Contents

Chapter I

Introduction

The importance of rural energy, especially domestic energy for household activities, has been recognised for a long time in India.[1/] Despite this, the domestic energy consumption pattern in rural areas is far less understood than for example, the urban energy consumption pattern. This is precisely so because of the difficulty in identifying and quantifying non-commercial energy[2/] (NCE) consumed in the households in a variety of forms and from many different sources. Being mostly available locally and of biological origin the consumption pattern of NCE, which is the predominent type of energy available in rural areas, cannot be understood except in the context of the eco-agricultural and socio-economic environment in which it is a part. Therefore it can be reasonably expected that for different regions of the country - different eco-agriculturally and socio-economically - the consumption pattern would also be different. During the last few years, a few isolated studies[3/] have thrown light on the pattern of energy consumption in rural areas of some regions. But no comparable studies exist for rural Kerala which is eco-agriculturally and socio-economically different from other regions of the country. No study is available for a region which has rich biomass resource endowments and an equable tropical climate. The purpose of our present study is mainly to fill this lacuna in energy consumption studies of the country by surveying a few villages in Kerala. An attempt is also made to understand the effects of system characteristics on the consumption pattern in different villages and different socio-economic groups representing the major agro-ecological regions of the State.

Energy and Development

Although the precise linkages between energy and development are complex and still imperfectly understood the importance of energy as one of the major factors for growth and development is widely accepted The degree of "affluence" of a country, expressed usually by the readily available yardstick of economic growth, per capita GDP, has generally a positive corelation with per capita energy consumption. The more the goods and services are produced, distributed and consumed per person, the greater will be per capita energy consumption. But per capita GDP as a proxy for economic development is generally acknowledged to be imprecise and inadequate for fully measuring development to be compared among different nations with differing economies, different cultural values and widely differing environmental settings and use of it in developing economies of the world is questionable. Similar is the case with per capita energy comparisons. Statistical comparisons might be possible among nations, but they tell nothing about the quality or form that is available or is needed for the given purpose. Consequently it is impossible to judge a country's well being just on the basis of total or per capita energy consumption or to state what level of equivalent energy consumption is to correspond to a specific level of economic development. Moreover it need not be necessary that countries should follow the patterns of development and energy utilisation adopted and historically determined by the developed countries, and alternate paths of development with a different energy utilisation pattern could be attempted in developing countries taking into consideration the specific factors prevailing in these countries.

Energy Consumption in Developing and Developed Countries

Both developing and developed countries are facing an energy crisis, especially after the many-fold increase in oil prices, during the 'seventies. But the dimension and the nature of the problem are quite different. The pattern of consumption of energy in developed countries is historically determined through energy-intensive production, distribution and consumption technologies which were evolved to suit their specific circumstances of capital abundance, labour shortage and cheap energy, especially from oil. Consequently an "energy-intensive life style" was evolved in every sector of the economy (in agriculture, industry, transport,household etc.,), resulting in centralised energy production for distant markets rather than decentralised production for local consumption. In contrast, most of the developing countries have an altogether different pattern of consumption. The most striking feature is their dependence on non-commercial energy obtained through decentralised production and consumed locally for subsistence-level activities. Roger

Revelle[4/] estimates that more than 5/6 of all the energy obtained from fossil fuels, hydroelectric and nuclear power (what is known generally as commercial energy) is used in developed countries and only a very insignificant portion is obtained from non-commercial energy resources. The reverse phenomenon prevails in the case of developing countries. Table 1.1 illustrates this sharp contrast for a few developing and developed countries. Reasonable estimates[5/] are that more than 90 percent of the total energy in African countries and some of the developing countries in Asia like Nepal is obtained from NCE. Thus we see that the consumption pattern in developed countries and developing countries are quite different. The nature of the energy crisis, therefore, is also different. In the case of developed countries the problem is one of whether they can resolve the energy crisis without cutting down their growth rates and standards of life attained through energy intensive technologies. In the case of developing countries the problem is whether they can achieve a higher standard of life for their people without energy becoming a constraint. There are also differences in terms of ecological and environmental impact of the energy crisis. The nature of the problem being different in developed and developing countries, it is inevitable that the approach and solutions will also have to be different.

The Dual Nature of Energy Consumption in Developing Countries

Even within developing countries there is no homogenity in the pattern of energy consumption. The dual nature of the society - a small, largely urban-based group and a large, mostly poverty-stricken mass of people living in rural areas - is clearly reflected in the energy consumption pattern also. Given the type of economic activities and resource endowment in rural and urban areas it is to be expected that the pattern of consumption also differ in rural and urban areas. The majority of the rural population do not have access to centralised power distribution and for their energy needs such as for agriculture, transport and domestic activities they depend on non-commercial energy. In some of the African and Asian countries, for which data is available, it is found that NCE account for more than 90 percent of total domestic energy consumption.[6/] Table 1.2 illustrates the pattern of rural/urban energy consumption in India and Bangladesh. The pattern is more or less similar in other areas as well and individual studies carried out by Makhijani (1975), Openshaw (1971), Earl (1975) and Eckholm (1975) for different countries confirm this. This pattern in energy consumption has greater implications. Decomposing total rural energy needs for different energy-consuming activities, it could be seen that most of the energy needs are for meeting the requirements of subsistance like producing food, cooking, lighting and transporting food and fuels. These are activities necessary for human survival, but contribute to economic growth only after crossing the threshold of subsistence. Energy necessary for subsistence varies with region, climate, life style, etc. even with in a country and there can be difference of opinion about the exact quantity of energy needed for subsistence. But the striking aspect of rural energy system in the developing countries is that the burden of subsistence is borne by the NCE and this fact merits deeper analysis. But unfortunately, except a few isolated studies, the diagnoses of the energy situation has concentrated on commercial energy sources and only peripheral interest has been shown to non-commercial sources. Our contention is that the issues involved in urban and rural energy systems are different and hence a different approach is needed for tackling each of them.

Energy Situation in India

With the help of the available data, we attempt a review of the Indian situation, to analyse the energy consumption pattern and to understand the important issues involved. The data used for analysis are not definitive but only indicative. In common with many developing countries, India also consumes a variety of energy forms ranging from electricity obtained from nuclear fuels to energy from cowdung. Table 1.3 shows the source-wise contribution and sector-wise consumption of commercial and non-commercial energy. Energy from animal and human power are not included in the above estimates. Revelle (1976) estimates these to be about 23 percent of total energy use in rural areas.[7/] Taking this into consideration, the total energy obtained from non-commercial sources of energy would be more than 50 percent of total energy consumption. Table 1.4 gives energy uses in rural India as estimated by Revelle (1976). In the rural areas, the Household sector and the Agricultural sector together consume more than 85 percent of the total energy consumption. Within each of these sectors NCE sources contribute about 90 percent of the total energy requirements of the respective sectors. It can be observed that more than 90 percent of total energy consumption in rural India are met from NCE sources. Domestic activities including lighting account for about 70 percent of the energy consumption.

Need for In-depth Studies

From the above analysis we see that the energy situation in India is not much different from any other developing agrarian economy. The Indian villages are almost totally dependent on NCE sources for their subsistence-level activities like agriculture and household activities. The most important sector consuming 70 percent of energy is the household sector (mainly cooking and lighting) which is absolutely necessary for survival. The implications of this are vital for planning for development, especially in the context of meeting basic needs of rural people.

For Kerala no systematic consumption study has been conducted so far and ours would be the first of its kind for this region. This thesis is divided into seven chapters. Chapter II reviews some of the important energy studies at the macro-level and shows their inadequacy to understand fully the complex energy system. Chapter III reviews some micro-studies and emphasises the need for diversified studies at a disaggregated level to bring out the influence of structural characteristics on energy consumption pattern. The scope, methodology and limitations of the study are outlined in Chapter IV. Chapter V deals with the general features and pattern of energy utilisation in the three sample villages selected for the study. The findings and results of the study are analysed in Chapter VI. Chapter VII gives our concluding observations.

Table 1.1: Aggregate Energy Consumption in a Few Developing and Developed Countires: 1970

(In million tons oil equivalent)

1 ton oil equivalent = 10 m cal

Form of Energy	India	Kenya	Japan	UK	USA
Coal	30.8	0.1	7.3	41.5	75.0
Oil	15.1	1.0	55.3	43.9	545.4
Gas	0.7	n	9.6	13.2	369.6
Electricity	4.2	n	8.9	17.6	128.9
Firewood	55.6	3.1	1.2	0.1	4.6
Dung	11.8	n	n	n	n
Plant residue	15.2	n	n	n	n
Cattle power	3.5	n	n	n	n
Man power	2.7	0.1	0.8	0.4	1.5
	139.8	4.3	189.6	136.6	1165.2

Source: Asok V. Desai, "Development and Energy Consumption" in Pachauri, R.K.(ed); International Energy Studies, 1980. p.143.

n = negligible

Table 1.2: Non-commercial and Commercial Energy Consumption in India and Bangaladesh

(10^6 coal equivalent tonnes)

		India	Bangaladesh
	Total	267	19.5
Total Energy	Urban	115	1.9
	Rural	152	17.6
	Total	103	2.0
Commercial	Urban	87	0.8
	Rural	16	1.2
	Total	164	17.5
Non-Commercial	Urban	28	1.1
	Rural	136	16.4

Source: Revelle. R; "Requirements of Energy in the Rural areas of Developing Countries" in Norman L. Brown (ed); Renewable Energy Sources and Rural Application in Developing World; AAAS selected symposium (1978).

Table 1.3: Energy source - sector matrix for India (1978)

(in MTCR)

Sector/Source	Household	Industry	Transport	Agriculture	Others	Total
Coal	4.0	50.50	12.40	-	1.90	68.80
Electricity	7.70	53.90	2.60	11.95	8.25	84.40
Oil	28.76	9.00	78.18	19.37	5.79	141.10
Commercial Energy	40.46	113.40	93.18	31.32	15.94	294.30
Non-Commercial Energy	200.00	50.0	-	-	-	250.00
Total	240.06	163.40	93.18	31.32	15.94	544.30

Source: Government of India, Report of the Working Group on Energy Policy (1979).

Table 14: Energy Uses in Rural India

Source of energy	Energy used (k cal)					
	Agriculture	Domestic activities	Lighting	Pottery, brick maling, metal work	Transportation and other uses	Total
Human Labour	0.59×10^{14}	0.39×10^{14}	-	0.01×10^{14}	0.09×10^{14}	1.08×10^{14}
Bullock work	1.35×10^{14}	-	-	-	0.26×10^{14}	1.61×10^{14}
Firewood and Charcoal	-	-			-	4.60×10^{14}
Cattle dung	-	6.78×10^{14}	-	0.75×10^{14}	-	1.86×10^{14}
Crop residues	-	-		-	-	1.07×10^{14}
Total from local sources	1.94×10^{14}	7.17×10^{14}	-	0.76×10^{14}	0.35×10^{14}	10.22×10^{14}
Petroleum and gas* fuel	0.08×10^{14}	-	0.42×10^{14}	-	-	0.50×10^{14}
Soft coke	-	0.14×10^{14}	-	-	-	0.14×10^{14}
Electricity	0.15×10^{14}	-	0.06×10^{14}	-	-	0.21×10^{14}
Total from Commercial Sources	0.58×10^{14}	0.14×10^{14}	0.48×10^{14}	-	-	1.20×10^{14}
Total local and Commercial	2.17×10^{14}	7.31×10^{14}	0.48×10^{14}	0.76×10^{14}	0.35×10^{14}	11.07×10^{14}

Source: Roger Rovelle; "Energy use in rural India" in Vaclav Smil and William Knowland (ed), '<u>Energy in the Developing World: The Real Energy Crisis</u>'; Oxford University Press, 1980, p.202.

*Energy used in fertiliser not included.

Chapter II

Review of Some Macro-level Studies in India

Principal Energy Needs of the Rural Community

Principal energy needs corresponding to human needs in rural areas are energy for agriculture (irrigation, draught power, transport of foodgrains, crop processing, storage, etc.), household activities (cooking, lighting, other household tasks, etc.), and village industries (potteries, brickmaking, etc.). Broadly the energy sources can be classified into animate and inanimate energy - animate sources being human energy and animal energy and inanimate sources being "commercial energy" and the biofuels. Commercial energy sources contribute only a very insignificant portion of the total energy needs and it is mostly biofuels like firewood, organic wastes including firewood that the villages consume.[8/]

Heterogenity of Energy Studies

Because of the predominance of biofuels or non-commercial energy in the rural energy system which is produced and consumed locally to meet local demands and not a commodity exchanged through a market or a centralised production system, rural energy is not easily subject to quantification. But this aspect of quantification of energy needs and flows is central to the task of rural energy planning and assessment. There are only a few studies in India on rural energy at the macro-level, but because of the peculiarities of the system (the difficulty in quantification, identification of sources, integration of different energy consuming activities and practical difficulty in separating them, the close relation between biofuel resources and the resource endowment of the villages, etc.) even they show considerable heterogenity in coverage, concepts and assessment. In this chapter we would review some studies done for India bringing out the differences in concepts and coverage.

Studies on rural energy at the macro-level can be broadly classified into three categories depending on the coverage.

1. Studies which do not separately consider rural energy but analyses it as part of overall energy system with emphasis on demand and consumption in various sectors and policy options available for meeting the projected consumption.

2. Studies which consider rural energy separately and analyses the sources and consumption.

3. Studies which consider only a particular sector among the different energy consuming sectors. In this section we would focus on energy consumption in the domestic sector with which we are concerned in this study.

Problem of Aggregation

Before discussing specific studies on the subject, we may discuss one important problem in all the studies relating to energy namely, the problem of aggregation.

While every form of energy can be measured in one physical unit or the other, their aggregation requires conversion into a common unit. This is necessary in order to understand the level of production and consumption of total energy. Several methodologies are employed for aggregation of energy. It is found that each agency/country adopts a specific methodology depending on the availability of data and the purpose for which aggregation is required. Defining energy equivalents of various forms raises problems to which there are no ideal solutions. In the earlier studies on energy-related issues in India, coal replacement measure was adopted as the common unit of measurement. Coal-replacement measure expresses the amount of coal that would have been needed to substitute the other fuels taking into account the efficiencies involved in typical cases of substitution. International studies use the coal-equivalent measure as the unit of aggregation. This expresses the heat content of each fuel in terms of an average measure. There are different units appearing in literature for expressing heat content like Btu, K cal, ton-oil-equivalent, etc.[9/] In India the first systematic study on energy namely the Report of the Energy Survey Committee (1965) used coal-replacement measure as the unit of aggregation. Subsequent policy oriented studies[10/] have also followed the same unit of aggregation because they felt that "the balance of convenience lay in continuing the unit of measurement which has come to be used widely in studies on energy in India". The biggest drawback in adopting this measure (coal-replacement measure) is its dependence on the efficiency of use of fuel in different sectors/industries. As the efficiency goes up or down the coal-replacement ratios are also changed to that extent. If the ratios are changed from time to time, the figures in different periods may not be strictly comparable. Estimates with energy input in terms of heat value (say, coal-equivalent) are also not ideal. Since they would not reflect the efficiency of usage, estimates could be underestimates or overestimates when considered in the context of using different energy forms for meeting a particular country's requirements from the available energy resource, for example, coal in the case of India. This might be the reason for choosing coal-replacement measure in India because of the availability of large coal resources.

Thus we see that the two commonly used measures of aggregation viz., coal-replacement measure and coal-equivalent measure have some limitations and no one measurement is inherently superior to other. Table 2.1 gives the differences in the conversion factors of coal-equivalent and coal-replacement measures. One should be very careful when comparing the Indian data which is set out in coal-replacement terms with international data which are normally set out in coal-equivalent units.

Policy-oriented Studies

In spite of the spate of publications that are being produced on the subject of energy, there are not many studies at the macro-level particularly addressed to rural energy consumption. The resulting lack of quantitative data has led to several problems. In the earlier studies the importance given to commercial energy is unmistakable, especially in the policy-oriented studies such as the Energy Survey Committee Report (1965), Report of the Fuel Policy Committee (1974) and Report of the Working Group on Energy Policy (1979). All the three policy-oriented studies primarily consider the overall demand and consumption for various sectors and project them for future years. They are mostly in the nature of estimating present consumption and projecting it for a future year setting out ways and means to achieve this consumption. Only in the latest of these studies (Report of the Working Group on Energy Policy (1979) a separate consideration of rural energy is done by assembling all the information available regarding consumption of commercial and non-commercial energy in the different sectors of rural economy. While some data are available regarding household energy consumption as a result of the periodic surveys undertaken by NSS (18th Round and 28th Round) the information base is woefully inadequate in respect of other sectors. Even the data on commercial energy is not amenable to disaggregation into rural and urban consumption and there are large gaps in our knowledge of rural energy needs. But the policy-oriented studies have, however, done yoemen service in providing sector-wise details of the present situation regarding energy sources and utilising activities, trends over last 25 years, and the forecasts for the future. But as Reddy[11/] points out the Reference Level Forecasts (RLF) are shown to constitute a set of energy demands which are prohibitively high relative to the country's energy resources that it becomes imperative to intervene by implementing alternative policies for improved energy productivity and production. For example the 2000 RLF corresponds to about 5.6, 4.5, 3.4 and 2.7 times the 1978-79 consumption of electricity, coal, oil and total commercial energy respectively which is a tall order considering the difficulty in attaining the present level of consumption with respect to every single energy source.

The data presented in these studies are also beset with problems because they cannot be used in completeness. The major handicap in these studies is in their consideration of NCE on which the rural energy system sustains itself. The contributions of human and animal energy, mostly used in rural areas, in the different sectors like agriculture, transport and domestic sector have not been estimated.[12/] Since a very significant part of the energy for agriculture and rural transport is obtained from animate energy sources, this could lead to significant errors in assessing the present energy consumption in rural areas and in the formulation of appropriate policy-measures. The omission is largely because information necessary for the formulation of a comprehensive rural energy policy is not available.

Problems in the Estimation of Inanimate Energy

The estimation of NCE, even after leaving out energy of animate origin, poses problems. Since this problem runs through most of the macro studies on energy we would discuss the issue in some detail.

Apart from animal and human energy, the specific items coming under NCE are mainly firewood, charcoal, dungcakes and vegetable wastes. Estimation of firewood and charcoal from output figures is quite tricky. We do not have reliable or even reasonable estimates of firewood and charcoal production. Recorded production from forest is only about 10 percent of the total consumption. The rest comes from unrecorded sources - collection from forests not accounted for and firewood from non-forest sources. Although we have estimates of growing stock and increment for the forest vegetation, the amount of firewood available in our forests is a matter of guess work because the estimates confine mainly to timber, and output from branches, twigs and leaves are not available. In the non-forest areas we do not have reliable estimates of even growing stock. Thus, we do not have reliable estimates from supply side. Even if accurate production/consumption data are available in a common measure such as cubic metres, they mask the differences in heat value of different wood, moisture content, combustiability, whether estimates are for stacked or solid volume and how much consumed for producing charcoal, etc. Depending on the contribution of each factor the estimates also vary considerably.[13/]

Estimation of cow dung used as fuel poses still more difficult problems.[14/] Many have attempted to estimate the dung produced by livestock and proportion used as fuel. Dung is produced as a byproduct of fodder intake and there must be a relation between the two. In order to establish credible limits to the total availability of dung we should know the total fodder intake by the cattle and fodder to dung ratio. Without elaborating the difficulties in estimating the fodder consumption we would analyse some important points qualifying for greater considerations. Fodder given to cattle is either dry fodder (straw) or green fodder. Straw production can be estimated by using straw-grain ratios (NSS, 1969 b, and ICAR, 1977) which differ considerably. For example, NSS gives much lower figures than ICAR data based on actual experiments for straw output. But even this is inadequate because part of straw output is consumed in alternate uses like thatching, fuel, etc., and some of the agricultural crops producing fodder are not taken into account. Apart from the supply from fodder crops, green fodder is available from pastures, waste lands, forest and from fodder trees. There are no figures on the quantities collected from these sources. Moreover straw consumption depends on the climate, availability of fodder, proportion of stall-fed animals to the total population and intensity of feeding. Thus, many assumptions have to be made in order to arrive at the gross energy intake of cattle. Briscoe (1979), Makhijani & Poole (1975) and Odend'hal (1972) makes such assumptions for calculating fodder consumption and dung production. Coming to fodder-dung ratio Odend'hal estimates the energy ratio of dung to fodder at 19.8 percent for the cattle of West Bengal village studied by him, which implies a dry-weight ratio of 31 percent. ICAR's (1977) estimate of feed consumption and dung production for a number of regions confirm this. One should expect dung output to be underestimated in uncontrolled Indian studies since a large proportion is not collected at all; this danger cannot be discounted even in ICAR surveys. Not all dung produced is useful. Only dung collected is useful. Dung has alternate uses also - as manure, other uses like for binding floors, etc. Reliable estimates are lacking in its different uses. Briscoe (1979) and Odend'hal (1972) summarises recent estimates on production of which 22 to 85 percent is estimated by different authors to be used as fuel. This will correspond to 48 to 97 million tonnes. Revelle[15/] accepts Henderson's[16/] estimate of 68 million tonnes used as fuel of which 83% is burned in rural areas.

The problem of estimation of vegetable wastes used as fuel is also complicated - alterate uses, no production figures, calorific value differences, moisture content, etc.

Need for Comprehensive Surveys

With these difficulties in estimation, only consumption studies can generate reliable data on NCE consumption in rural areas. But comprehensive surveys of all the energy needs of all sectors in a village community have not yet been carried out. The only sector where detailed consumption surveys have been done is the household sector by the NSS and NCAER. The estimates of NCAER and NSS are used in the policy-oriented studies . But the methodologies adopted for the surveys by NSS and NCAER are questionable and we would look into them later in this chapter. From the above discussion we find that the policy-oriented studies, though useful in many ways, are not adequate for fully understanding the rural energy consumption pattern.

Henderson's[17] study of Indian energy sector also does not treat rural energy separately except for a reference to the rural electrification programme. His estimation does not include the contributions of human and animal energy. The estimates on NCE in his study is also based on the NCAER survey results.

Two important studies for India where contributions of animal and human energy are considered in the estimates of aggregate energy consumption, are done by Revelle (1976) and Desai (1978). Revelle's estimates are only for rural India whereas Desai estimates for the whole of India. Estimation of NCE except animal and human energy is based on NSS and NCAER surveys the merits or demerits of which we shall consider later in this chapter. Estimation of human and animal energy varies in both studies because of the difference in assumptions made. The difficulties in estimating their contribution in the total energy consumption are many. Since our purpose in this study is limited concerning only the direct energy flows in the household sector we are not discussing the literature on human and animal energy in this chapter in detail. However the subject is discussed in some detail in Appendix I.

From the discussion in Appendix I it is evident that although there are difficulties in estimation the contribution of human energy and animal energy is significant in the total energy consumption, especially in rural areas. Revelle (1976) estimates that in rural India 23.5 percent of total energy consumption comes from animal and human energy sources. For the agricultural sector 77 percent comes from these sources. Desai (1979) estimates this to be 88 percent. There could be difference of opinion as to the exact contribution of human and animal energy in the rural energy system. Comprehensive consumption surveys, however, are needed to estimate precisely the nature and extent of energy sources in rural communities.

Some Important Studies on Household Energy Consumption

The third type of macro studies consider only particular sectors of the economy. The sector in which detailed consumption surveys have been done is the household sector; probably because of the importance of this sector in the energy situation of the economy. This sector is the largest consumer of energy accounting for about half of the total energy consumption, excluding animate energy[18]. Energy is primarily used in the households for cooking and lighting. The most significant feature of energy consumption in this sector is its dependence on NCE. It is estimated[19] that (Table 2.2) 51 percent in urban areas and 80 percent in rural areas came from NCE. According to another estimate[20] more than 90 percent of cooking needs are met from NCE in rural areas. Only in urban areas there is significant use of commercial energy for cooking and lighting.

The first systematic study of domestic energy consumption was conducted by NCAER (1965), the basic figures of which are used by the policy-oriented studies to calculate per capita domestic energy consumption in rural and urban areas. A three-stage stratified sampling design has been adopted for the survey, with district as the primary unit, village as the secondary and household as the unit of selection in the final stage of sampling. The variables used for the purpose of stratification of the districts are in the order of importance the following:

(i) Per capita gross agricultural product as a measure of economic level;

(ii) Percentage of agricultural population to total rural population;

(iii) Proportion of population in places with 5,000 to 10,000 population to the 1961 population in places under 10,000;

(iv) Density of population; and

(v) Percentage increase in population during the decade 1951-61.

The National Sample Survey Organisation (NSSO) has also done two surveys on domestic energy consumption in 1963-64 (18th Round) and 1973-74 (28th Round). This was on the same line as that of the consumption expenditure survey regularly being done by NSSO and no separate methodology was adopted for domestic energy consumption survey. Both NCAER survey and NSS on domestic energy suffers from several weaknesses, especially in the rural context. The rural energy system dependent mostly on biological resources, has a close relation with the eco-system, apart from other socio-economic characteristics. So for the purpose of meaningful analysis, a typology of Indian villages, based on ecological factors including biological resources endowment pattern, land use pattern, socio-economic factors, life style, geographical locations, etc. should have been developed and then the consumption survey should have been carried out. But in both NCAER Survey and NSS this approach was not developed and thus methodologically inadequate for studying domestic energy consumption.

Another shortcoming in the above surveys is that none of them involved actual measurements of energy (fuels) consumed. They followed the 'recall' method for estimating quantities of energy consumed. What reflects in this type of survey is only the households' impression of the quantities they consume and not the actual quantities. Reasonable estimates could be generated in respect of commercial forms of energy like LPG, Kerosene, electricity which had to be purchased from market or available through centralised and recorded sources. But in the case of NCE coming in a variety of forms and sources this could be only somewhat approximate because villagers fail to give the exact consumption of fuels in terms of any unit of measurement like Kilogram for different fuel materials. Besides the NCAER survey covered only 4 months and they could be biased on account of seasonality factors.

Comparing per capita domestic energy consumption for rural areas in the two National Sample Surveys one finds that consumption of biofuels show a fall of about 50 kg/year while the kerosene consumption rose by 4.4 kg. As Desai points out, even after assuming that per capita consumption has not changed during the period, "the replacement ratio would appear to be impossibly large".[21/] A possible explanation is the improvement in efficiency of usage. But no studies on efficiency of usage are available and it is impossible to verify the reliability of estimates by any independent studies.

Comparing the NSS (1963-64) figures with NCAER (1962) figures in detail it is found that the figures for firewood are fairly close viz. within 20 per cent except for North Zone (See Tables 2.3 and 2.4). The dung cake estimates differ considerably, so also estimates of vegetable wastes and charcoal.

The impression one gets after considering the different studies is that there are problems of methodology and concepts and no ideal solutions for estimating energy consumption have emerged from them. The estimates, thus, differ accordingly depending on the assumptions and concepts followed and it is not possible to verify the estimates independently because of the absence of adequate diversified and comparable studies. It is in this context of generating adequate, diversified and comparable data in respect of the different eco-agricultural and geographical regions that our study of some villages in Kerala is relevant and useful.

Table 2.1: Conversion Factors of Different Energy Units

Original Unit	Million tonnes coal-replacement (MTCR)	Million tonnes coal equivalent (MTCE)
1 M tonne coal	1.0	1.0
1 M tonne oil	6.5	2.0
10^9 kwh (TWH)	1.0	0.123
1 M tonne firewood	0.95	0.95
1 M tonne dry animal dung	0.40	0.48
1 M tonne vegetable waste	0.95	0.84

Source: Government of India, Report of the Working Group on Energy Policy, (1979).

Table 2.2: Energy Consumption in Households: Share of Fuels and Sources of Supply in MTCR, (Metric Tonn Coal Replacement)

Energy Forms	Rural Per Capita Energy				Urban Per Capita Energy			
	Percentage share	Purchased	Collected	Home grown	Percentage Share	Purchased	Collected	Home grown
1. Electricity	0.6	100	-	-	5.9	97	3.0	-
2. Oil products	16.9	100	-	-	30.2	100	-	-
3. Coal products	2.3	65.1	34.9	-	13.7	95.6	4.4	-
4. Firewood	68.5	12.7	64.2	23.1	45.5	73.7	14.8	11.5
5. Animal dung	8.3	5.1	26.2	68.7	3.2	49.1	12.3	38.6
6. Others	3.4	8.9	61.0	30.1	1.5	71.2	28.8	-
7. Share of commercial fules	20%				49%			
8. Share of Non-commercial fuels	80%				51%			

Source: NSS (28th Round); Report of the Working Group on Energy Policy, 1979.

Table 2.3: Estimates of Domestic Per Capita Energy Consumption (Rural) Comparison of NSS 18th Round, 28th Round and NCAER (1962)

Energy Form		NCAER (1962)	NSS (18th Round) (1963-64)	NSS (28th Round) (1973-74)
Coal	(kg)	-	3.5	3.7
Coke	(kg)	3.8	1.7	3.1
Charcoal	(kg)	0.6	0.7	0.1
Dung cake	(kg)	126.8	100.8	72.7
Wood	(kg)	234.7	270.1	251.9
Other Fuels	(kg)	72.3	9.8	12.4
Kerosene (Litre)		5.8	4.4	8.8
Gas (cum)		-	-	-
Electricity (Kwh)		0.5	0.3	2.2

Source: Asok V. Desai (1978) "Energy Output and Consumption in India - A methodological Review", Working Paper No.97, Centre for Development Studies, Trivandrum.

Table 2.4: Rural Per Capita NCE Consumption - Comparison of Estimates for Different Zones (kg/year)

Zone	FIRE WOOD		VEGETABLE WASTES		PUNG CAKE		CHARCOAL	
	NSS*	NCAER**	NSS	NCAER	NSS	NCAER	NSS	NCAER
North West	256.12	236.61	19.02	27.98	91.32	169.06	3.05	0.27
West	276.29	314.64	28.64	19.26	33.46	108.67	0.21	0.16
South	279.36	241.88	13.74	184.68	10.96	98.22	0.29	0.74
East	265.23	237.20	73.99	79.56	130.18	103.13	0.26	1.17
North	260.87	171.11	12.89	34.93	160.76	168.11	0.51	0.23
India	269.19	234.69	32.36	72.34	100.75	126.76	0.73	0.57

Source: Same as Table 2.3

*NSS (1963-64)
**NCAER (1962)

Chapter III

Review of Some Micro Studies on Rural Energy

Inadequacy of Macro Studies on Rural Energy

Analysis at the aggregate level typically compares the availability of energy with aggregate requirement of energy and implicitly assumes that distribution is taking place according to need. One finds that such a method at the global (macro) level is obviously flawed because wide-spread chronic malnutrition for example co-exists with an adequate supply of food. Similarly whether the context is global or local, the issue of distribution is crucially related to the control of available resources which is dependent on the structure of social organisation. This aspect has not been given much attention in most of the studies. The studies reviewed in the previous chapters, except where sample surveys are referred to, implicity assume "some sort of homogenous, harmonious and cooperative village social structure" in which those who own the means of energy production share the energy produced with those who own no energy resources.[22/] But these studies are decontextualising rural energy which simultaneously is physical and social So it is better to place rural energy in a structural context to analyse the dynamics of the system. An 'apolitical' (as Briseoe (1979) puts it) approach to rural energy problems without taking into consideration the structural nature of the rural energy crisis seems inadequate in this context. Thus the formulation of rural energy problem is critical. Depending on the formulation of the problem different solutions and policies could emerge. The systemic relationships require a systemic response and understanding. National averages are inadequate in this context. The social-structural-environmental determinants of energy consumption can be understood only by studies at the local level in a site-specific manner, not in isolation but in holistic terms.

The availability of energy (mostly biofuels) in a village is the function of the particular resource endowment of the village - the aggregate agricultural, forestry and other land based resources, livestock and human resources. This is dynamically linked and integrated into the social, cultural, economic and environmental structure of the village system. Thus to gain real insight into the dynamics of the rural energy system one needs multiple perspectives. Studies at the local level are inevitable in this context. With this objective in mind we discuss below some micro level studies done in India and elsewhere. The case studies are discussed in greater detail to show the dynamic relationship the rural energy systems have with the historical and social characteristics of village communities.

Social Structure and Rural Energy Systems

John Briscoe's (1979) study of Ulipur village in Bangladesh analyses energy use in the village in the light of the social and economic structure prevailing there. Ethnic, religious and economic cleavages divide Ulipur into two unequal districts. Roughly one-sixth of the villagers are landless Hindus who own no energy resources. The bulk of villagers are Muslims spread across a poor-rich spectrum. The unequal distribution of energy and economic resources gives the rich Muslims (about 16 percent of total households) control over 55 percent of land, 79 percent of trees and 42 percent of cattle.

Briscoe's study involved 50 percent of the population. Detailed information was collected on productive activities, production and distribution of food, fodder, fuel and fertilisers and based on direct measurement, estimates and flows across different sectors were computed. Non-commercial energy account for the total energy requirements of the village. 54 percent of the total energy consumption is obtained from crop residues, 20 per cent from firewood and 25 percent from other sources including animal dung. The energy system in the village is frugal and virtually nothing is wasted in this agricultural eco-system. The system is also complex with several products and by-products each of which is used for several purposes. The complexity and tightness make the process of understanding the energy system contingent on an appreciation of the agricultural and livestock systems. Decisions on cropping pattern and crop-mixture are crucial with respect to energy consumption also because crop residues account for 54 percent of total energy consumption in the village.

These aggregate data conceal a pattern of energy use and resource ownership in Ulipur that is quite non-uniform. Hindus and Muslims obtain their fuels from spatially distinct sectors. Access to different types and sources of fuel varies with different ethnic groups and with in each ethnic group with different economic classes. So the energy consumption pattern, like food production and other economic activities, is controlled by the social structure. Briscoe therefore asserts that "the village energy system must be explained in terms of Ulipur's social and economic organisation and to understand how villages of different classes will meet their fuel needs in the future it is essential to understand how the present form of social organisation have evolved and how they appear to be changing.

Previously poor individuals relied on the patron-client relationship that existed in the village to reduce their burden with respect to fuels. They were allowed to take crop residues and cow-dung from the land of patrons free of cost. This traditional reciprocity that perpetuated the feudal hierarchy acquired an apparent stability with regulations, governing the appropriate behaviour of patrons and clients, embedded in the social norms of the community. Briscoe then analyses the disintegration of this social order and the changing relations of productic because of the introduction of high-yielding crops, mechanisation, importance of non-agricultural sources of income, increasing agricultural labour, etc. He analytically shows how these social changes manifest themselves in the energy system of the village. Crop residues for domestic use are no longer available for the poor Hindus and agricultural labourers and procurement of sufficient fuel is a critical problem for many families.

Disputes between different classes of people over fuel resources are frequent and there is a gradual breakdown of the distribution mechanism. The landless people have therefore been forced to steal or to find money to purchase cooking fuel which otherwise would have gone for purchasing food. Briscoe ends his analysis of Ulipur village energy system with a caution that the major obstacle to the success of any rural energy programme aiming for a fair deal to the poor of the poorest is compulsively political in nature like redistribution of wealth. Apolitical prescriptions holding out the promise of a solution to the energy problems while leaving the political and economic structures intact are bound to fail.

Briscoe's study is very much relevant in the Indian situation also because of the similarities in social and economic structure. The study gives greater insight into the dynamics of the rural energy systems and analyses some of the more crucial and relevant issues which are more often overlooked in similar studies. It also proves beyond doubt the inadequacy of national level studies in understanding the determinants of energy consumption in rural areas and the fact that the solution to the rural energy problem is closely linked with the solution to the problem of inequality and power.

Energy Consumption Pattern of a Karnataka Village

An important study for India was done at the ASTRA group of the Indian Institute of Science, Bangalore.[23/] The rural energy consumption patterns of 6 villages in the dry belt of Karnataka state were studied. The objective of the study was limited to deriving a detailed knowledge of current pattern of energy consumption in rural areas in order to derive a pattern of technologies required for the satisfaction of energy needs. This study does not attempt to analyse the data in relation to the social structure prevailing in the villages. But the generated data based on actual measurements, questioning and observation gives the total picture of energy consumption in the studied villages and many important points emerge.

Taking the case of household energy consumption we find that the per capita firewood consumption (which accounts for 96 percent of the total energy consumed in cooking) does not show much variation viz., 639 kg $\pm$ 53 kg per capita per year and there is a poor correlation between land holding and per capita firewood consumption. This is obviously so, because of the need for cooking fuel irrespective of the class differences. But the relative difficulty with which different classes of people obtain the cooking energy need not be uniform. Correlation between land holding and dependence on different sources of firewood (gathered, own land collection and purchased) would have given this information. But because of the limited objective of the study this aspect has not been analysed in this study.

An interesting point that emerges from the study is the regional speficity in the forms of fuel used in villages. About 96 percent of the energy for domestic consumption comes from firewood and only 3 percent comes from agro-wastes. Cow dung is not used as fuel at all. The Report of the Working Group on Energy Policy (1979) assumes that the shares of firewood, agro-wastes and cowdung in the total NCE consumption are 65 percent, 15 percent and 20 percent respectively. Therefore it is doubtful, that without adequate micro level studies reliable estimates could be generated on the relative contribution of different forms of energy used in rural areas.

The dependence of non-commercial energy supply and consumption on the resource endowment and accessibility is evident in the villages studied when inter-village variations are considered. Two villages which are closer to forests depend to the extent of 73 to 81 percent on gathered fuel and only 4 to 9 percent on purchased fuel. In the other two villages - both deficient in tree and shrub resources - only 32 percent is obtained from gathered and 50 percent from purchased sources. But distribution of energy and source dependence across different economic classes are not considered in the study. When alternate rural energy policies are considered, these issues are crucial especially if the burden of resource deficiency in villages is mostly borne by the landless labourers and marginal farmers who detain a part of their consumption expenditure for purchasing fuels.

The study by ASTRA is a pioneering effort for understanding the energy consumption pattern in rural areas of India and the wealth of information generated familiarises the energy planners to the hitherto overlooked but important issues involved in rural energy planning.

L.J. Milhayi's[24] study on the nature, economic and social significance of charcoal production in Zambia and D. Bajracharya's[25] study on the fuel wood and food needs of a hill village in Nepal also emphasise the need for socio-structural analysis of rural energy systems and the linkage of micro phenomenon with macro structures.

The two micro-studies discussed in detail in this chapter introduce some important principles for social and technical analysis of rural energy issues. They can be only understood as an interaction of natural, technological and social factors. Rural energy cannot be addressed as an isolated natural or technical problem but only in an overall developmental context which is a historical and socio-cultural phenomenon and there is no direct one-dimensional answer to the rural energy problem. In this context similar studies across diversified situations will help in better understanding of the problem for intervention through useful policy formulations.

Chapter IV

Scope, Objectives, Methodology and Limitation of the Study

Scope

From the review of literature in the earlier chapters, we know that rural energy supply and demand patterns are frequently integrated into the complicated eco-agricultural and socio-economic system of the villages. The characteristic feature of the rural energy system is its almost total dependence on energy of organic origin for the energy needs. The energy of organic origin is predominently constituted by biofuels and this, in a village, is generally a function of the resource endowment of the village eco-system - the aggregate living resources of the village. The possibility of inflow of energy from an exogenous source can be assumed to be very limited in the rural energy context because of the prohibitive costs of import of energy and the very low levels of purchasing power of the villagers and hence mainly dependent on traditional energy sources. Therefore, villages can be assumed to be closed system with respect to energy. In this context, national level studies - macro studies - and national averages for rural energy demand and consumption are inadequate to understand the dynamics of the system and could be misleading when considered for evolving alternate energy policies and other policy-oriented actions. The regional specificities with respect to resources, socio-economic characteristics, eco-agricultural factors and tradition necessitate the study of rural energy system at the microlevel for formulating policies at the macro-level.

The only systematic study that we have come across in the Indian context, is by the ASTRA group of I.I.Sc., Bangalore. Their study, as we have already discussed in earlier chapters, was for a dry area in Karnataka State covering 6 villages which are ecologically and socio-economically more or less homogenous. It was found that even within this apparently homogenous eco-system inter village differences in the types and sources of energy, attributable to the resource specification of the villages could be established. But it would be erroneous to interpret or generalise on the basis of region specific studies like the one that was done in Bangalore. The only feasible alternative is to have more and more studies in different eco-agricultural and socio-economic regions.

In the above context rural Kerala is different from other regions of the country in many crucial respects. With a tropical moist climate, the area is well endowed with biomass resources. The region has abundant tree growth and a typical land utilisation pattern. A major portion of the area is under coconut crop (about 7 lakh hectares) and its influence in the economic situation of the region is substantial. One important feature of coconut tree is that apart from the kernels, it gives a variety of byproducts almost all of which can be and are utilised for burning in the rural households. Coconut trees, being plentiful, contribute substantially to the rural hearth. But even within Kerala, the dependence on coconut trees for energy needs varies due to the differences in locality factors, land utilisation, etc. In short, the structure and composition of energy needs and consumption may be different in different regions of the State depending on the micro-eco-system and socio-economic characteristics.

We know from the literature on rural energy that of all the different energy consuming sectors the most important one is the household sector. Not only does this sector consumes the largest proportion of the total energy consumed in rural areas, but also the energy consuming activities of the sector are absolutely necessary for survival (like cooking and lighting). In our study, therefore, we confine ourselves to the household sector only, being the most crucial sector in rural energy planning as well as in the context of satisfying basic needs of rural people.

In order to accommodate all the nuances and intricacies involved in the domestic energy consumption patterns we have adopted the case study method for understanding the consumption pattern. To reflect the specificities in resource endowment and socio-economic characteristics, we have taken 3 villages (socio-economic groups) different in resource endowment, land utilisation, socio-economic factors, etc. One is a coastal village with very scarce and limited resources, another is an agricultural village with plenty of coconut trees and other agricultural crops and the third a village near forest area with plenty of resources not within the system but in nearby forest areas. Apart from the differences in resource endowments there are differences in socio-economic characteristics also among the villages like in the distribution of assets, occupational structure, etc.

In every village energy-consuming activities were identified and the types, sources and quantities of energy used by different socio-economic classes were analysed to find out the behaviour of households and classes, within a village and across villages. Attempt has also been made to determine the dependency of households on different sources of energy and how households adjust themselves to the scarcity of energy resources within the system and how the adjustments are correlated to the overall resource position of the village eco-system.

Objectives:

The main objectives of the study are the following:-

i. Estimation of the quantity of energy used for domestic purpose, the types and source of energy consumed by households and different socio-economic classes of people within a village and the differences across villages having diversified resource endowment and socio-economic characteristics.

ii. To find out inter-village differences in consumption pattern and how far the resource endowments and socio-economic characteristics of villages affect the consumption patterns.

iii. To estimate the dependence on coconut trees for domestic energy needs in different villages.

iv. To find out how unequal distribution of fuel producing assets affects the pattern of consumption and how the lower classes adjust themselves with respect to energy needs in villages different in resource endowments.

Methodology

Three villages - one in coastal area, one in an agricultural area and another village near forest area - were identified. These three villages correspond to the three major agro-climatic zones of the state namely, the low-land, the mid-land and the high-land regions. Each village identified does not conform strictly to administrative division of villages, but forms a compact socio-economic group with clear boundaries. Each of the three villages selected for study is a ward in the respective panchayats. The villages were selected in such a way that they form more or less representative areas in the different regions. The criterion for selecting these particular villages was one of operational convenience.

Cluster sampling technique has been adopted for the survey in all the three villages. The house numbers of respective villages were collected from panchayat office and each village is divided into clusters of 10 households each. Out of the total clusters in a village 5 clusters comprising of 50 households were randomly selected for survey.

A detailed questionnaire was prepared and finalised after field-testing in a pilot survey. There were two sets of questionnaire. One was intended to seek information on household characteristics, land holdings and land utilisation. Information was also sought on type of vessels used for cooking, lighting appliances, cooking stoves and also rough estimates of different types of fuels used during the week prior to the week of survey. Another questionnaire was used to collect detailed information on the actual quantities of different types of fuels used and their sources, actual quantities of food consumed, time of cooking, duration of cooking, number of people eating out, etc. between two successive visits to the household. This questionnaire sought information at a much detailed and disaggregated level and was repeated 7 times to collect information for a full week by visiting every household daily.

To get reliable estimates of energy consumed in households, the survey has to be organised with utmost care. A very significant portion of the energy requirement is obtained from "unorganised" collections from homesteads or nearby areas and the respondents do not have good idea of the exact quantity of consumption in terms of a standard unit of measurement like kilogram. So, dependence on "recall" method alone for the quantities consumed might lead to significant errors in estimates. To avoid this in our survey the fuel materials were actually weighed using spring balances every day for every household. Moreover, in order to limit the errors to the minimum, one week's consumption was monitored with visits daily to each household. This is a departure from the household surveys conducted elesewhere.

The energy consuming activities in a household - mainly cooking and lighting are mostly done by the women-folk of the household and they constitute the respondants in a household energy survey. For the successful conduct of the survey it is important to establish good rapport with the respondents, especially so when the investigators have to deal with women-folk. Moreover, in our survey, in order to weigh the fuel materials kept in the households, access to the kitchen of the household was necessary - a proposition which is not pleasantly taken by the household members. This might also generate doubts and hostility in the minds of villagers regarding the motivation of the investigation and become uncooperative leading to significant errors in the data. Given the circumstances and nature of survey the ideal persons to serve as investigators are the people among the villagers themselves. This is precisely what we have done when the investigators were chosen for the survey. For all the three villages we had the educated unemployed from the corresponding village. In two of the 3 villages the investigators were women who are the best for household energy survey with easy access to the households and their kitchen and for making the respondents as cooperative as possible.

For every village there were five investigators, each investigator taking care of 10 households. Every household has been visited daily for 8 days. Questionnaire seeking general information was used only on the first day of the survey. Questionnaire seeking information on energy utilising activities and consumption was reapted every day. As we have already indicated the important difference of our survey from other household energy surveys is the reliance on actual measurement of fuel materials to find out the daily energy consumption of households. The stock of different types of fuel materials kept in each household was weighed every day using spring balances. The depletion in stock of every type of fuel found in the subsequent visit to the household was calculated. Where households had used any extra quantity of fuel materials other than from the stock weighted and kept on the previous visit, "recall" method was adopted to get information on the extra quantity consumed by the household. The respondents were shown weighed quantities of different types of fuel materials to give them an idea of the amount consumed from sources other than the weighed stock in the households. The same method is followed where the households did not have any stock of fuel materials. The depletion in stock of fuel materials was added to the quantity used from other sources to get the actual consumption in kilograms between two successive visits. The last visit to the households was done more or less at the same time as that of the first visit to get exactly one week's consumption data.

Consumption of kerosene was obtained by the following formula.

Consumption of Kerosene for the week = (stock at the beginning of the survey + total purchases of kerosene) - stock at the end of the survey.

Electricity consumptionwas obtained from the electricity meter readings.

Energy needs of the households are met from a variety of fuel materials differing in calorific value. For purposes of understanding the level of production and consumption and the dependence of the households on various components of the eco-system, the energy produced or consumed in different forms have to be aggregated using a common unit of measurement. Standard values are available for certain forms like firewood, kerosene, electricity, etc. But for certain other forms especially for different coconut products calorific values are not available. So we have designed a simple experiment and found out the comparative heat value of the different fuel materials keeping firewood as a standard. The details of the experiment and the comparative heat values are given in Appendix II. The firewood equivalents (FWE) thus obtained is a combined value taking into consideration the calorific value and efficiency of burning. All forms of fuel materials except kerosene and electricity have been brought to FWE with the help of conversion factors for analysing the results of survey.

Limitations and Problems

Investigation for 8 continuous days in each household was tedious and a considerable imposition upon the hospitality of the respondents. The methodology involved detailed observations, weighing of fuel materials as well as easy access to kitchens of the households and but for the fact that investigators were from the same village it is doubtful whether the respondents would have been as cooperative and understanding enough while the survey was conducted.

In many households the fuel materials were not collected and kept in stocks but were scattered around the homestead. On many occasions the investigators had to collect, bundle and weigh them which were time consuming and difficult activities specially when fuel materials come in a variety of forms and every bit of them has to be accounted separately.

The moisture content of different forms of fuel materials varies and depending on the amount of moisture content the calorific value per unit also varies while burning. Energy is needed for evaporation of moisture. But due to practical difficulties we have not taken into account the moisture content of fuel materials consumed by households. To a certain extent this error is minimised while weighing fuel by keeping fuel materials dry enough to be able to use it immediately. Moreover, in the experiment designed to find out the FWEs of fuel materials, they were used in "as used" condition and not on a dry basis. But inspite of all these precautions there could be errors due to moisture content.

Another limitation of the survey is that the survey design does not take into account the seasonality factor. The survey was conducted during the months of October-November, i.e. end of the North-East monsoon. Since household energy requirements were met mostly from fuel materials of biological orgin it is possible to have different consumption pattern during the other seasons. Therefore, the results of our survey should be used cautiously as far as the seasonality factor is concerned.

Chapter V

General Features and Pattern of Energy Utilisation in Sample Villages

This chapter is divided into two sections. Section one deals with general features of the three sample villages and how households in the villages are grouped into socio-economic classes for analysing the data in subsequent chapters. In the other section we discuss the energy-utilising activities of the villages and their differences among the three villages and, within village, among different socio-economic classes.

General features of the village

Three villages in Trivandrum District were selected for the study - Puliyur village in Nandiyode Panchayat, Kunnummel village in Pazhayakunnummel Panchayat and Puthiyathura East Kandom in Karumkulam Panchayat (See District map). Trivandrum district is the southern most district of Kerala State with a warm, humid, and tropical climate and high rainfall. Based on physical features the district can be divided into three natural divisions* - (i) the mountainous region on

*The classification into natural divisions is the one followed in Census. The region which lies below 25 feet above mean sea level is classified as low land, between 25 feet and 250 feet above M.S.L. as midland, and remaining region which is covered by forest and mountains as high land.

the eastern part - highland, (ii) the flat coastal belt on the western part - lowland, and (iii) the undulating area in between the above two regions - midland. The district has a high rate of literacy (about 70.5% in 1981 census) and density of population (1184 per Km^2 in 1981 census); density of population being highest in the coastal areas and lowest in the highlands.

In this district workers form 28.58 percent of the total population and of the total working population 14 percent are cultivators and 30 percent are agricultural labourers. 74 percent of the population live in rural areas. The important agricultural crops raised in the district are rice, tapioca, coconut and cash crops like pepper, tea, arecanut and rubber. The forests in the district are mostly confined to the eastern mountainous parts. Forests are predominantly of semi-evergreen and moist deciduous types with evergree patches in between.

A brief description of the 3 villages selected for the survey are given below:

Puliyur Village (Village I)

Puliyur village is a part of Nandiyode panchayat occupying the eastern parts of Trivandrum district. In our survey this village is taken as the representative village for an area bordering forests. The reserve forests of Palode Forest Range touch the boundaries of the village. Villagers have easy access to the forests which consist mostly of cashewnut and anjili (Artocarpus) plantations of the Forest department. The principal agricultural crops are rice, tapioca, coconut, arecanut and pepper.

There are 179 households in this village including a few households under the One lakh housing scheme.[26/] The occupational structure of the heads of the households is given in Table 5.1. The village is electrified and the sources of water are wells, ponds and streams which are easily accessible.

The village is well endowed in fuel resources within the system with coconut and other trees. The biomass resources of the nereby forests (maximum distance from the farthest household to the forests is less than 0.5 km.) are available for the villagers although it is officially not permitted. An important feature of the village is the absence of firewood shops in the area.

Kunnummel (Village II)

Kunnummel village forms part of Pazhayakunnemmel panchayat and occupies the northern parts of Trivandrum district. This village is typically agricultural in character. The main crops grown are rice, tapioca, coconut, rubber, etc.

There are 499 households in this village. The occupational structure is given in Table 5.2. The village is electrified and sources of water are wells, pond and rivers. This village is also well endowed in fuel resources, available from coconut and other trees and agricultural residue but not from forests.

Puthiyathura (Village III)

Puthiyathura forms part of Karumkulam panchayat and occupies the coastal belt of Trivandrum district. This village is taken as the representative of the coastal villages. There are 502 households in this village. Fishing and allied activities form the occupation of the majority of villagers. Except for a limited amount of coconut cultivation there is not much agricultural activities in this village. The occupational structure is given in Table 5.3. The village is highly populated and has very little fuel resources within the system. The general socio-economic level of the village is very low with a low rate of literacy and high density of population and a fluctuating income.

Almost all the daily requirements are purchased. The village market assembles every evening. Pipe and well form the sources of water.

Classification of Households

Within a village the economic assets, including fuel producing assets are not distributed equitably. It is therefore expected that the patterns of consumption of household energy might also vary in the households depending on the class to which it belongs. Accordingly the households were grouped into different classes in each village. Analysis at this disaggregated level is expected to provide a deeper understanding of crucial issues linked to the social and economic structure of the village. Operational land holding of households is taken as the basis for grouping. Since land is the pre-requisite for the production of biofuels (villagers depend almost totally on biofuels for their domestic energy needs) the different land classes represent also the relative inequality in fuel producing assets and is reflective of the socio-economic structure of the village like income distribution. (See Tables 5.4, 5.5 and 5.6)

In the present study the households are grouped into five classes as given below:

Class 1. 0.00 - 0.10 acres
2. 0.11 - 0.50 acres
3. 0.51 - 1.00 acres
4. 1.01 - 2.50 acres
5. Above 2.50 acres

This classification on the basis of operational land holding is found to be feasible only for villages I and II. In the coastal village no household has more than 10 cents of land and the classification followed for the other villages becomes impossible here. The village is dependent on fishing and there is no land-based occupation. Therefore it is only possible to classify the households according to their ownership of means of production (in this case fishing crafts and gears) and which seems the most appropriate basis for classification. We have, therefore grouped the households in this village accordingly and is as given below:

Class 1. Labour households

2. Household with own fishing craft/gear (Kattamaram).

3. Households with own fishing craft (small boats)

4. Other occupations.

Energy Utilising Activities

To define the magnitude and structure of domestic energy needs in the villages under study, we have to analyse the energy flows for different energy-consuming activities in the households. The essential energy-consuming activities in households are cooking and lighting. Energy is also consumed for some other household activities like heating water for bath, ironing clothes, parboiling paddy, etc. But energy consumed under the latter category is generally negligible compared to the major energy-consuming activities of cooking and lighting.

Table 5.7 gives the details of energy-consuming activities except cooking and lighting for the three villages surveyed. It could be seen that energy spent on these are very insignificant and so, for the purpose of our analysis, we include them also under cooking activity and not treated separately.

The break up for cooking and lighting in the total energy consumption in the 3 villages are given in Table 5.8 and illustrated in figure 1. Cooking accounts for about 95 percent of the energy consumption in all the villages. This is slightly more than the national average of 90.7 and slightly less than the figure for the villages studied in Karnataka State which is around 97.5 percent. But the variations are very minor and so like other regions in the country, energy requirements in the villagesstudied are predominantly for cooking only.

Cooking

Rice and Tapioca form the staple food of all the people in the villages. It consists of breakfast, lunch and dinner. In some well-to-do households snacks are prepared on some days. Breakfast is either prepared in the household or taken outside the households in teashops. It is also seen that sometimes breakfast is bought from tea shops and eaten. Quite often, the households manage itself with whatever is left after the previous day's dinner. The food habits of the people in the 3 villages are analysed and tabulated in Tables 5.9, 5.10 and 5.11 which give the information for different land or ownership classes.

It is seen that the number of persons taking freshly prepared breakfast increases with increase in land holdings and income and the opposite is true in the case of cold break fast (i.e. leftovers of the previous day's dinner). Obviously the poor households cannot afford to prepare breakfast every day and manages with whatever is available in the households. This proposition is generally true for all the three villages studied but with one significant difference in the case of coastal village (Village III). The habit of eating breakfast outside the household is very prevalent and it is seen that the number of persons eating out increases with income. This could be due to the peculiar socio-occupational system prevailing in coastal villages. Fishing is a very arduous vocation involving the male population only. Partly because to equip themselves for the hazardous occupation and partly because of socio-cultural conditions of coastal villages it is observed that the distribution of food within the household favours the male members of the family who make it a point to eat out when nothing is prepared in the household or when adequate food is not available in the household. From the energy consumption point of view, it can thus be observed that part of the energy consumption which otherwise would have been consumed in the households is actually consumed outside the households in tea shops and hotels.

Lunch usually consists of rice or tapioca or both and some curries. Number of persons eating lunch outside the household is small in all the villages. In households with higher income the number of curries prepared are more. In many households dinner is not prepared separately and the members eat the rice and tapioca prepared during lunch time. Some curries are prepared afresh during dinner time. In Village I (See Table 5.9) 50 percent of members, except in the households of the lowest and highest classes, consume what is prepared at lunch. In the highest land class only about 30 percent and in the lowest class about 84 percent take food prepared along with lunch. Simultaneous cooking of lunch and dinner found in many households reduces their fuel consumption to a considerable extent. In Village II (See Table 5.10) also the pattern is similar except that the number of persons taking cold dinner are more than that in Village I. Irrespective of the income class the number of persons consuming hot dinner in Village III is much more than that in other villages. It is observed during the survey that the most important meal in the households in the coastal village is the dinner. The reason for this difference from the other two villages might be their unique life-style linked to the occupation. In Village I only 15 percent of total rice consumption is prepared during dinner and in Village II it is 6 percent. But in Village III, 56 percent is prepared during dinner.

Consumption of Food

As we have seen earlier, rice and tapioca account for most of the food consumed by the villagers. The quality of rice and tapioca consumed in different households varies and consequently energy consumed for cooking also varies per unit quantity of rice or tapioca.[27/]

Per capita consumption of rice and tapioca in Village I and Village II do not show large variation (see Table 5.12 and Table 5.13). Whereas 2.33 kgs. of rice is consumed in Village I, in Village II the per capita consumption of rice is 2.60 kg/week. In the case of Tapioca the per capita quantities are 2.61 kgs/week and 2.16 kgs/week respectively for Village I and Village II. But in Village III consumption of rice is much lower (See Table 5.14) than the other two villages. Per capita consumption of rice is only 1.72 kgs/week, but per capita consumption of tapioca is higher at 3.01 kgs/week.

Inequality in consumption of food is more pronounced within the village. Considering per capita consumption across land/ownership classes it is evident that the households in the lower classes consume less than the higher classes. But this pattern is found true only in the consumption of rice. It is not true in the consumption of tapioca which is considered to be an inferior food. Per capita consumption of tapioca increases initially with increases in land holdings/income but decreases again in the case of highest classes.

Comparing the figures for food consumption in the three villages, it is evident that Village III has generally low consumption standards and poverty is comparatively greater than in the other two villages. This might not be to the extent as made out in the Tables because of the consumption of a large quality of fish which they get from their daily catch.

Examining the food consumption patterns of the three villages the following points emerge:

i. Per capita consumption of rice in Village I and II does not show much difference. But inequality is more pronounced within villages across social classes.

ii. In the coastal village rice to a certain extent is substituted by tapioca for which consumption is higher than that for the other two villages. Increased consumption of tapioca, considered an inferior food, is indicative of the poor nature of Village III.

iii. Rice is consumed more by the richer classes and tapioca by the poorer classes.

Cooking Appliances

Villagers in all the three villages are using two types of cooking stoves - closed chulah type and open chulah type. The distribution of different types of stoves is given in Table 5.15 and Figure 2. It is found that closed chulah type is used commonly and the number of households using open chulah type is very insignificant. Some households use both types. Closed chulah type is of two varieties. One is completely made of mud paste covered with a smear of cowdung and the other is of burned clay type procured from markets.

Cooking is generally done by women of the household. Since our purpose in this study is only to estimate the direct energy flows, we have not attempted to calculate the energy spent for cooking by way of human labour. No attempt is also made to calculate the efficiency of the different types of stoves used.

Lighting

Apart from cooking the other important energy consuming activity is lighting. Villagers are seen using either electricity or kerosene for lighting. All the three villages studied are electrified (see Tables 5.16, 5.17 and 5.18). Village I being comparatively inaccessible, electricity lines are not brought to all areas of the village. Some households also use vegetable oil and candle sticks, but they are used more as a religious ritual than for lighting. Energy used in battery operated torches and match boxes are also not included in the estimates; their contribution to total energy consumption being very insignificant. Electricity is not used for other purposes like pumping water or for cooking in any of the households surveyed. In a few well-to-do households electricity is consumed for radios, electric irons, etc. but their use is very insignificant. It can be safely assumed that electricity is predominantly used for lighting only.

In all the households where electricity is not used, kerosene is used for lighting. In Village I it is observed that in some of the electrified households also kerosene is used to some extent for lighting because of frequent power failure and low voltage. Kerosene is solely used for lighting. In our sample only two households were having kerosene stoves; but due to difficulty in getting kerosene these households were also not using kerosene during the period of the survey. It is observed during survey that a small quantity of kerosene is used in many households to start a fire in the hearth. This quantity being small and difficult to quantity, no separate information has been sought on this account.

The lighting appliances (using kerosene) used mostly confine to the categories of open wick lamp and chimney lanterns. The most commonly used one is the open wick lamps.

Summary

For our study three representative villages representing three agro-climatic zones have been chosen. Each village is distinct in respect of resource endowment. Since land is the pre-requisite for producing bio-fuels, the households are classified on the basis of operational land holding except in the case of coastal village where ownership of means of production is considered appropriate and taken as the basis for classification. The main energy utilising activities in all the villages are cooking and lighting, with cooking accounting for about 95 percent of the household energy consumption. We have then analysed the food habits and food consumption across villages and within village across different land or ownership classes. This analysis provides a deeper insight into the distributional aspects of food and how food habits are related to the energy requirements of the households. The types of lighting and cooking appliances used by households as well as the extent of lighting activity are also discussed in this chapter.

Table 5.1: Distribution of Occupation of the Heads of Households: Village I (Puliyur)

Occupation	Number of households
Agricultural Labour	9
Casual labour	17
Cultivators	10
Salaried employees	5
Others	7
Total	48

Table 5.2: Distribution of Occupation of the Heads of Households: Village II (Kunnummel)

Occupation	Number of Households
Agricultural Labour	5
Casual Labour	8
Cultivators	25
Salaried employees	7
Others	5
Total	50

Table 5.3: Distribution of Occupation of the Heads of Households: Village III (Puthiyathura)

Occupation	Number of Households
Crew Labour	21
Kattamaram fishing	19
Small boat fishing	6
Others	4
Total	50

Table 5.4: Classification of Households and Household Characteristics Village I (Puliyur)

Sl. No.	Land Class (acres)	No. of HHLDS	Average family size	Average Income (per month)	Average land area (acres)
				Rs.	
1	0.00 - 0.10	17	4.6	228	0.06
2	0.11 - 0.50	9	6.0	293	0.28
3	0.51 - 1.00	9	6.2	471	0.90
4	1.01 - 2.50	8	5.3	270	1.37
5	Above 2.50	5	7.2	1042	3.30

Table 5.5: Classification of Households and Household Characteristics Village II (Kunnummel)

Sl. No.	Land Class (acres)	No. of HHLDs	Average family size	Average Income (per month)	Average land area (acres)
				Rs.	
1	0.00 - 0.10	6	5.8	225.0	0.025
2	0.11 - 0.50	10	4.3	225.0	0.366
3	0.51 - 1.00	14	5.0	283.9	0.835
4	1.01 - 2.50	12	5.10	366.3	1.651
5	Above 2.50	8	5.63	462.5	3.49

Table 5. 6: Classification of Households and Household Characteristics, Village III (Puthiyathura)

Sl. No.	Ownership class	No. of HHLDs	Average family size	Average Income (per month)	Average land area (acres)
				Rs.	
1	1	21	6.10	263.1	0.01
2	2	19	5.42	281.32	0.03
3	3	6	5.83	526.67	0.03
4	4	4	5.5	827.5	0.02

Table 5.7: Energy utilising Activities of the Villages other than Cooking and Lighting

(per week/per household)

Village	Average Number of times water heated for bath	Average Number of times ironing done	Average quantity of paddy parboiled (in kg)
I Puliyur	1.06	.14	1.39
II Kunnummel	1.98	.04	0.92
III Puthiyathura	0.16	-	-

Table 5.8: Energy for Lighting and Cooking as a percentage of the Total Energy Consumption

Village		Energy for cooking	Energy for lighting
I	Puliyur	94.7	5.3
II	Kunnummel	96.5	3.5
III	Puthiyathura	95.1	4.9

Note: For purpose of converting various types of energy the following factors were used.

Firewood	: :	3800 K.cal/kg.
Kerosene	: :	9000 K.cal/litre
Electricity:	:	860 K.cal/KWH

Table 5.9: Food Habits in Village I (Puliyur)

(Per week)

Land Class (acres)	Number of persons taking breakfast			Number of persons taking lunch			Number of persons taking dinne:		
	At home	Outside home	Cold	At home	Outside home	Cold	At home	Outside home	Cold
0.00-0.10	19.65	1.88	11.12	29.82	0.76	-	4.88	0.24	25.00
0.10-0.50	27.22	6.22	11.12	40.0	2.22	-	20.67	0.44	19.67
0.51-1.00	34.78	4.89	6.11	40.44	2.67	-	21.67	-	20.78
1.01-2.50	35.00	-	7.25	36.75	-	0.88	14.63	0.13	22.13
Above 2.50	48.0	1.20	3.00	50.00	1.40	-	33.80	1.00	16.40

Table 5.10: <u>Food Habits in Village II</u> (Kunnummel)

(per week)

and Class (acres)	Number of Persons taking breakfast			Number of persons taking lunch			Number of persons taking dinner		
	At home	Outside home	Cold	At home	Outside home	Cold	At home	Outside home	Cold
.00-0.10	10.33	2.67	16.83	38.50	3.50	-	6.33	-	35.67
.11-0.50	12.50	1.40	13.60	28.90	1.70	-	0.60	0.30	29.90
.51-1.00	23.07	1.57	10.00	33.93	0.57	-	1.93	0.36	32.21
.01-2.50	22.17	1.08	15.25	34.00	2.75	-	6.25	0.50	28.83
ove 2.50	34.00	0.50	7.25	42.63	1.25	-	12.13	-	26.50

Table 5.11: Food Habits in Village III (Puthiyathura)

(per week)

Ownership Class	Number of persons taking breakfast			Number of persons taking lunch			Number of persons taking dinner		
	At home	Outside Home	Cold	At home	Outside Home	Cold	At home	Outside home	Cold
1	4.10	12.05	20.29	37.00	1.57	0.76	30.52	0.76	11.10
2	1.32	15.89	20.16	34.16	1.21	1.32	29.21	0.79	7.84
3	3.0	20.67	16.33	35.50	0.17	-	22.67	0.67	13.17
4	8.25	25	10.25	39	0.75	0.50	29.75	0.50	10.5

Table 5.12: Per Household Consumption of Food in Kgs. Across Land Classes (Per Week): Village I (Puliyur)

Land Class (acres)	Average consumption of rice	Average consumption of tapioca
0.00 - 0.10	9.33 (2.03)	11.5 (2.51)
0.11 - 0.50	13.50 (2.25)	17.11(2.85)
0.51 - 1.00	13.99 (2.25)	17.61(2.84)
1.01 - 2.50	14.21 (2.71)	12.5 (2.38)
Above 2.50	19.96 (2.77)	17.3 (2.41)
Average per capita consumption/ week	(2.33)	(2.61)

(Figures in parantheses give per capita consumptions)

Table 5.13: Per Household Consumption of Food in Kgs. Across Land Classes (Per Week) Village II (Kunnummel)

Land Class (acres)	Average consumption of rice	Average consumption of tapioca
0.00 - 0.10	11.09 (1.90)	13.17 (2.25)
0.11 - 0.50	10.24 (2.38)	10.20 (2.37)
0.51 - 1.00	11.80 (2.36)	11.86 (2.38)
1.01 - 2.50	13.82 (2.71)	11.17 (2.20)
Above 2.50	20.14 (3.58)	8.50 (1.51)
Average per capita consumption/ week	(2.60)	(2.16)

(Figures in parantheses give per capita consumptions)

Table 5.14: Per Household Consumption of Food in Kgs. Across Ownership Classes (Per Week): Village III Puthiyathura

Ownership Class	Average consumption of rice	Average consumption of tapioca
1	9.7 (1.59)	18.7 (3.07)
2	9.24(1.71)	17.41(3.21)
3	10.14(1.74)	18.33(3.15)
4	13.46(2.44)	7.82(1.43)
Average per capita consumption/week	(1.72)	(3.01)

(Figures in parentheses give per capita consumptions)

Table 5.15: Types of Cooking Appliances used by Villagers

Name of Village	Number of HHLDS using open stoves	Number of HHLDS using closed stoves	Number of HHLDS using both
I Puliyur	3	39	6
II Kunnumel	4	46	-
III Puthiyathura	2	40	8

Table 5.16: Energy Consumption for Lighting in Village I (Puliyur)

(Per week)

Land Class (acres)	No. of HHLDs	No. of HHLDs Electrified	Consumption of Kerosene (Litres)		Consumption of electricity (Standard Units)		Average consumption of kerosene/ HHLD (Non-electrified HHLDS)	Average consumption of electricity HHLD (Electrified HHLDS)
			Per HHLD	Per Capita	Per HHLD	Per Capita		
0.00–0.10	17	3(17.6%)	1.06	0.230	0.71	0.15	1.11	4
0.11–0.50	9	3(33.3%)	1.16	0.192	1.61	0.27	1.25	4.8
0.51–1.00	9	6(67%)	0.98	0.158	3.22	0.52	1.48	4.85
1.01–2.50	8	3(38%)	1.19	0.224	1.75	0.33	1.45	4.67
Above 2.50	5	5(100%)	0.98	0.136	5.6	0.79	1.45	5.6

Table 5.17: Energy Consumption for Lighting in Village II (Kunnummel)

(Per week)

Land Class (acres)	No. of HHLDs	No. of HHLDs Electri-fied	Consumption of Kerosene (Litres)		Consumption of electricity (Standard Units)		Average consumption of kerosene/ HHLD (Non-electrified HHLDS)	Average consumption of electricity/ HHLD (Electri-fied HHLDS)
			Per HHLD	Per Capita	Per HHLD	Per Capita		
0.00-0.10	6	1(16%)	0.7	0.12	0.83	0.14	0.84	5
0.11-0.50	10	4(40%)	0.62	0.15	1.90	0.45	0.98	4.75
0.51-1.00	14	6(43%)	0.75	0.15	2.07	0.41	1.11	4.83
1.01-2.50	12	9(75%)	0.47	0.09	4.16	0.82	1.61	5.55
Above 2.50	8	8(100%)	0.19	0.03	6.13	1.08	-	6.13

Table 5.18: Energy Consumption for Lighting in Village III (Puthiyathura) (Per week)

Ownership Class	No. of HHLDS	No. of HHLDS Electrified	Consumption of Kerosene (Litres)		Consumption of electricity (Standard Units)		Average consumption of kerosene/ HHLD (Non-electrified HHLDS)	Average consumption of electricity/ HHLD (Electrified HHLDS)
			Per HHLD	Per Capita	Per HLD	Per Capita		
1	21	8(38%)	.59	.10	1.62	.29	.89	4.25
2	19	6(32%)	.68	.12	1.35	.24	.93	4.25
3	6	4(67%)	.45	.07	2.83	.49	1.35	4.25
4	4	3(75%)	.27	.05	3.13	.57	0.90	4.46

TRIVANDRUM DISTRICT MAP

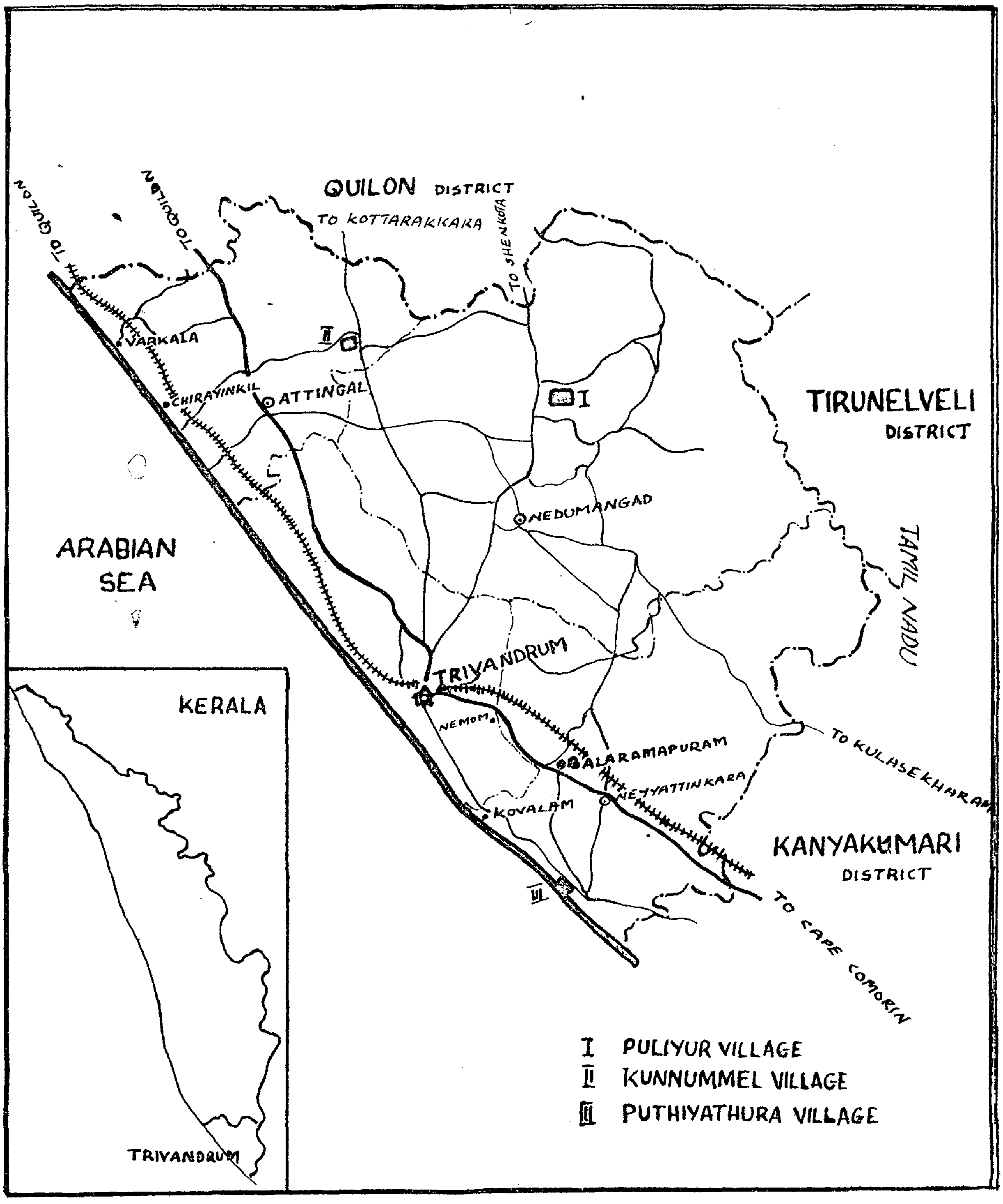


FIG.1:.ENERGY FOR COOKING AND LIGHTING AS A PERCENTAGE OF TOTAL ENERGY CONSUMPTION

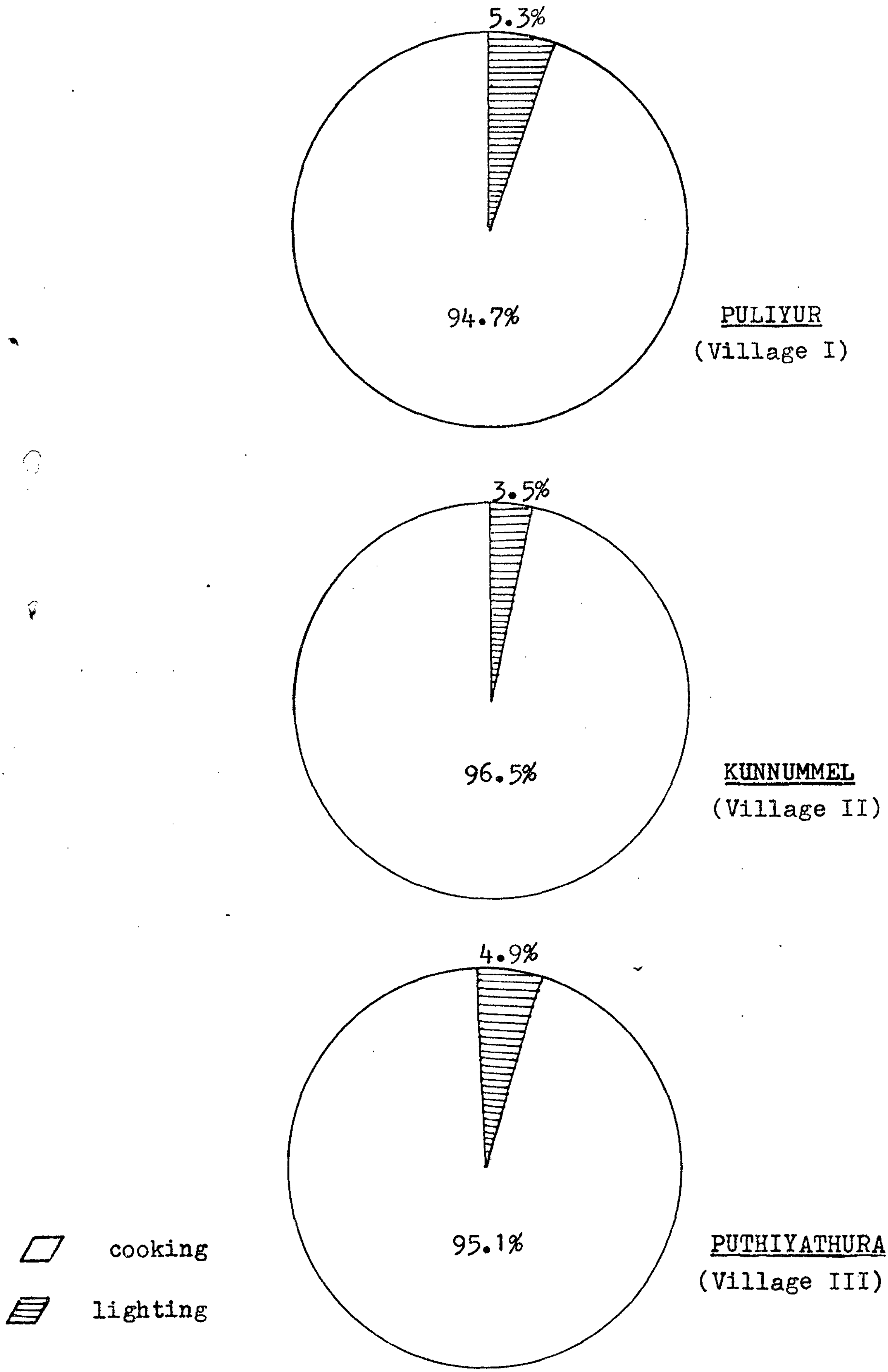
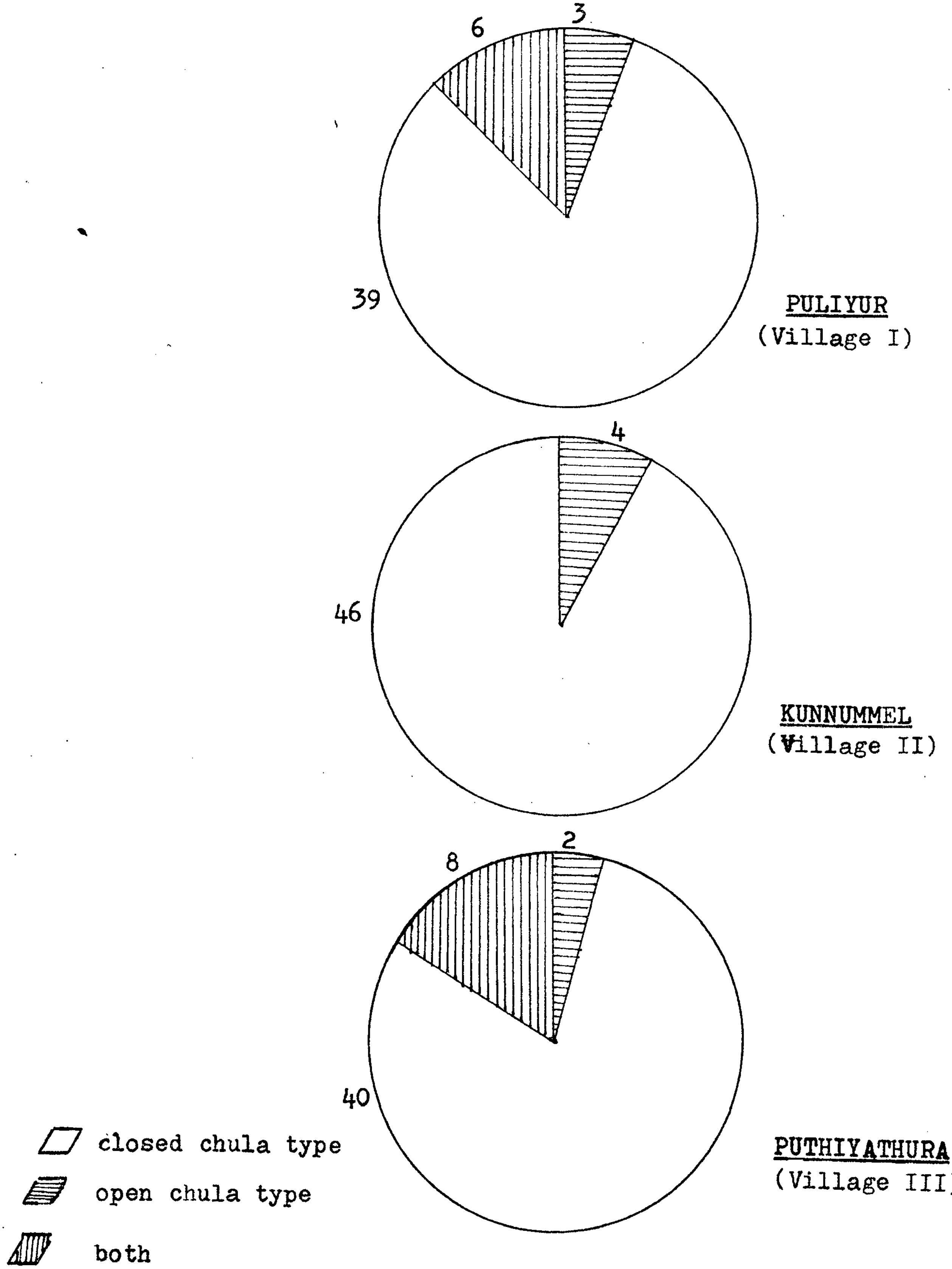


FIG.2: TYPES OF COOKING STOVES USED IN VILLAGES



Chapter VI

Findings and Results of the Study

Commercial forms of energy such as electricity, Kerosene, etc., provide only a fraction of the energy requirements of the households in villages. These forms of energy are used only for lighting and for which the dependence on them is total. More than 95 percent of the total domestic energy requirements are met from the Non-commercial energy (NCE) which is used totally for cooking. The break up of total energy for cooking and lighting given in Table 5.8 is also the measure of NCE and commercial energy dependence of the households. In this chapter we will discuss energy consumption for cooking and lighting separately.

As explained earlier in the analysis we include only energy directly consumed or flows directly involved in household sector and do not include energy spent indirectly like human energy spent for household tasks. However, non-inclusion of indirect consumption of energy will not alter the conclusions drawn otherwise because the quantity of energy spent on these activities is very minimal. In the study conducted by ASTRA (1980) it is seen that human energy spent on domestic activities is only 6 percent of the total domestic energy consumption. This should be much lower in the case of Kerala villages because of the absence of long journeys for fuel collection, less energy spent for fetching water, absence of regular grazing activities, etc. which form the major human-energy consuming activities.

Resource Endowment and Types of Energy (fuel) Materials Consumed

NCE is solely used for cooking. In Chapter V we have seen the extent of the activity. The important NCE forms used in the households are firewood including branches and twigs, coconut fuel materials, agricultural wastes and other miscellaneous things. An important feature of the villages in Kerala is the absence of use of cowdung as fuel material.

For better understanding of the contribution of different types of energy (fuel) materials, we have broadly classified them into three categories:

i. Firewood including branches and twigs,

ii. Coconut products, and

iii. Others

a. Inter-village Variations

Table 6.1 illustrates the contribution of different types of fuel materials for the three villages. The most striking aspect is the importance of coconut trees in the domestic energy system of the villages. About 42 percent of the total NCE requirements is met from them when all villages are considered (See Figure 3). This is naturally because of the unique land utilisation pattern in Kerala with coconut occupying the pivotal role in the agricultural economy of Kerala. From the energy point of view this is a major departure from other regions of the country and in a way helps the villages in reducing the burden of finding out energy resources.

In the study by ASTRA group firewood constitutes about 90 percent and agro-wastes about 6 percent of the total domestic energy consumption. Strictly going by energy terminology coconut products should be included in agro-wastes and if so the contribution of agro-wastes in domestic energy requirements becomes substantial viz. 50 percent; contribution from firewood also is 50 percent. At the national level the share of firewood is 65 percent and agro-wastes only 20 percent, the rest being animal dung.

Availability of NCE in a village is closely related to the fuel-producing assets of the village or the energy resource endowment of the village eco-system viz., the aggregate forestry resources available at the disposal of the village, the tree growth and agricultural crop residue in the system. The resource endowment being different in the three villages under study there are differences in the types of fuel materials (energy producing materials) consumed and it is found that the types of fuel closely relate to the resources available (See Table 6.1 and Figure 4). Village I with accessible forestry resources and tree growth gets 62 percent of its energy requirements from firewood and only 32 percent from coconut products. Village II gets only 42 percent from firewood and 45 percent of its requirements is met from coconut products, obviously because of the predominantly agricultural nature of the village. Village III is significantly different from the other two villages (this village is totally deficient in fuel producing assets) and all its energy requirements have to be met exogenously. There is no scope also for collecting fuel materials from nearby private holdings. In this village about 49 percent of its requirements come from firewood and about 49 percent from coconut products, most of them coming from outside the village through markets. But it is important to note that in this village also dependence on coconut products is substantial probably because coconut products are available for a price from nearby areas.[28/]

Consumption of agro-wastes (excluding coconut products) and other miscellaneous fuel materials also reflects the relationship between resources and types of fuel used. Village II with more agricultural activities gets 12 percent from this category and Village I gets 5.4 percent. Village III gets only 2.5 percent from agricultural-wastes which is also indicative of the extent of agricultural activities.

b. Intra-village Variations

Till now we have been looking at NCE consumption treating village as a unit. But the behaviour within each village is also not uniform with respect to the types of fuel materials used. It varies with the social class a household belongs to. When the households are classified into groups based on operative land holdings the differences are clearly brought out (See Tables 6.2.1, 6.2.2 and 6.2.3). As land holding increases there is an increase in the coconut products consumed as a percentage of the total quantity of fuel materials used (See figure 5). In the higher land classes this percentage comes down again but still remains at a much higher level than for the lowest classes in Village I and almost at the same level as that of the lowest class in Village II. This dampening effect on the consumption of coconut products in the highest classes may be due to the inferior nature of coconut products in calorific value[29/] and whenever enough firewood is available households tend to use it more. The highest land classes are in a position to use more firewood also because of their dominance over firewood producing assets.

In Village I firewood consumption as a percentage comes down initially as the households move up in land classes and again picks up in the highest classes. In the lowest land class, firewood contributes 77 percent of the total energy consumed. This comes down to 63 per cent and 50 per cent respectively in the next two higher classes and again increase to 56 percent in the highest class. The increased consumption of firewood (as a percentage) observed in the lowest land classes of the village is due to the availability of firewood free of cost from the nearly forest areas. In the case of Village II there is an increasing pattern of firewood consumption as households move up in land classes. Firewood consumption as a percentage increase from 33 percent to 49 percent as the households move up in the land classes. In Village III there is allround deficiency of fuel materials and the different classes do not show any pattern in the type of fuel materials used.

Dependency on the Types of fuel and Fuel Producing Assets

The dependence on different types of fuel has to be viewed also with respect to the fuel producing resources available in the village (See Tables 6.3.1, 6.3.2 and 6.3.3). In the tables we have compiled information on land holdings, number of coconut trees (above 3 years old) and number of other big trees* (above 125 cms girths at B.H). Although there are still other fuel-producing assets at the disposal of the households, the above information will give an idea of the distribution of major assets in the three villages and within each village among different classes. Garden land area per household in

*Rubber trees not included.

Village I is about 0.82 acres and on an average each household has 26 coconut trees and 5 big trees. Village II has 1.26 acres of garden land per household and on an average 46 coconut trees and 6 big trees. Village III has very meagre fuel producing resources. From the table it is evident that Village II has more endogenously available fuel producing assets than Village I, with almost double the number of coconut trees.

Within the village concentration of fuel producing assets is in favour of the richest classes. 27 per cent of the households in Village I control 70 per cent of the land area, about 59 per cent of coconut trees 67 per cent big tree growth whereas the lowest two classes having 54 per cent of the households control only 9 per cent of land, 11 per cent of coconut trees and 14 per cent of big tree growth. This highly skewed distribution of assets remains true in the case of village II also. 40 per cent of the households in this village controls 75 per cent of land, 73 per cent of coconut trees and 75 per cent of big trees whereas 32 per cent of the households control only about 6 per cent of land, 7 per cent of coconut trees and 8 per cent of big tree growth. In Village III the question of inequality in asset distribution is irrelevant because of its very minimal assets.

From the above analysis certain aspects of NCE consumption in the villages studied emerge. The types of fuel materials used in the village are those which are available within the system or which is accessible to them; in other words depends on the resource endowment of the village. When it is not available in the system, or villagers have no access to the resources, fuel materials have to come from outside the village but from nearby areas through markets. Depending on the resource endowment of the village the types of fuel used and their extent also vary.

Within the village also there is no uniformity in the types of fuels used. Depending on the land class the extent of use of different types of fuel materials vary. It is also seen that there is preference for firewood to coconut products and the households in the higher land classes use more firewood than coconut products.

Sources of Energy

In the sample villages, energy for domestic use comes from three sources viz., purchased fuel, procured from one own's land and collected from outside one's own land. In the earlier chapter we have seen that the ownership of fuel producing assets are not distributed equally among villages as well as among different classes within the same village. The inter-village and intra-village variations in asset distribution (distribution of energy resources) could lead to definite patterns of energy consumption. Our purpose in this section is to find out how far these variations manifest themselves in the consumption patterns.

In Village I the sources of energy for domestic use are residue of agricultural crops, (coconut materials, tapioca, stems, arecanut products, etc.) firewood from the trees owned by the households and firewood from the nearly forests. There is no firewood shop in this village but a certain amount of transactions do take place through the Kanikkars (local tribal people). They collect firewood from the forests and sell them to the villagers for their daily expenses. This is the only source to get firewood for a price. Firewood is collected by villagers also from the nearby forests free of cost. In Village II the residue of agricultural crops, firewood from the trees owned by households and firewood purchased from firewood shops constitute the sources. In village III only a very small quantity of fuel materials is obtained from the coconut trees and other small shurbs owned by the household and the major portion of them comes through the daily market and firewood shops. Figures 6 and 7 and Tables 6.4.1 (A,B & C) and 6.4.2 (A, B & C) give the break up of fuel purchased, fuel collected from own land and fuel collected from outside one's land for all the three villages. It is evident from the tables that each village depends differently on different energy sources for domestic use. The different patterns emerge because of the difference in resource endowments of the villages. 44 per cent of the total NCE requirements in Village I is obtained from outside one's own land, but in the case of Village II contribution from this source is only 17 per cent and in Village III only 5 per cent. The heavy dependence on outside collection in the case of Village I is closely related to the availability of resources from the forests nearby. 89.5 per cent of outside collections in this village come in the form of firewood and from observation it is found that almost all of which come from the forests (See Table 6.5). Even the contribution shown as purchased firewood is collected from forests, for the only source for purchasing firewood is from Kanikkars who are the only persons trading in fire-wood in the village. If this portion is also included in the category, outside collections amount to 76 per cent of total consumption of firewood in the village in which form 62 per cent of the household energy needs are obtained.

In Village II the predominent source of energy for domestic use is collection from the land owned by the households. Unlike in Village I there is not much scope for collection from outside free of cost, although some collections do take place from lands owned by other households. The contribution from home grown fuels is highest in this village accounting for about 76 per cent of the total MCE consumption in the households. This could be because of the following reasons.

i. More land area available for producing fuel (average land area per household is 1.26 acres which is much higher than in Village I viz., 0.82 acres and village III 0.02 acre).

ii. A land-use pattern giving rise to substantial area under coconut plantations which give about 45 per cent of the non-commercial energy requirements.

iii. There is not much collection from outside the village system.

As explained earlier Village III has, on the whole very little fuel producing assets and consequently the energy materials produced in the system are also minimum. In this village also scope for collections from outside the village is very limited. Thus the households have no other way except to purchase fuel from firewood shops and market. The striking aspect of energy consumption in this village is its almost total dependence on markets for the daily fuel requirements. About 88 per cent of total NCE consumption in this village is purchased and for this a part of the earnings of the villagers is exchanged - on an average 18 per cent of their total earnings (See Table 6.6).

Social Structure and Dependence on Sources of Energy

So far dependence of the villages on different sources of energy was considered although each village was a homogenous unit. But access to different sources is far from evenly distributed among the different social classes within each village. It is found to vary with class and is largely governed by the social structure.

Classifying households on the basis of land holdings we find that the unequal distribution of land and fuel producing assets in a village give rise to unequal dependence on different sources for the energy requirements of the households.

Tables 6.4.1 (A, B & C) and 6.4.2 (A, B & C) give the behaviour of different classes in each village. Households in the lowest land class in Village I get 75 per cent of their NCE requirements from collection outside one's own land and the households in the next class get 60 per cent from outside collection. The next three higher classes get only 21 per cent, 29 per cent and 6 per cent respectively. The opposite is true in the case of dependence on collections from land owned by households. The highest three land classes with concentration of land resources and fuel producing assets depend on collections from own land to the extent of 70 percent, 66 per cent and 77 per cent respectively. A limited amount of fuel is also seen purchased by all the households. The percentage of purchased fuel is found to be highest in the highest land class. This is precisely because of the availability of firewood cheaply from Kanikkars and preference of firewood to coconut products by the households.

In Village II the households in the lowest class get 73 per cent of their NCE needs from collection outside the household. These are the fallen firewood or coconut materials from nearby private lands and quite often collected without the knowledge of the owners or stolen from fields. In all other land classes the collection from own-land increases as the land holdings increase from 74 to 100 per cent. The lowest class of households purchase about 20 per cent of their total NCE consumption from firewood shops. This percentage of purchased fuel is the highest among all the classes in this village. The percentage of purchased fuel gradually decreases as the land holding increases. It is thus evident that the lowest class of people are the most deprived of all in the domestic energy system.

In examining the behaviour of the households in Village III where endogenous energy resources are minimum we find that dependence on purchased fuel is very heavy. In all social classes (based on ownership of means of production)dependence ranges from 82 to 96 per cent. There is not much variation in the different classes of households. We thus find that for studies on domestic energy which is dependent on organic fuels, classification of households based on income/occupation is inadequate. If households in Village III are also classified on the basis of land holdings, as in the other two villages, all the households come under, class I (0 - .10 acres) and therefore the classification is appropriate reflecting the close correlation between land holdings and consumption pattern. Although all the households spent a good part of their earnings for purchasing fuels, from Table 6.6 we find that the lowest income groups spend the highest percentage of their earnings for fuel. The expenditure as a percentage of total income decreases as the income goes up. For example, the lowest two classes spend 24 per cent and 22 per cent respectively, whereas the other two classes spend only 12 per cent and 9 per cent respectively. In short like in the other two villages here also the lowest classes are the most affected.

The extent of dependence of the different classes on different sources is clearly brought out from Tables 6.7, 6.8 and 6.9 in which households are assigned to a group based on its extent of dependence (0-20 per cent, 20-40 per cent, 40-60 per cent, 60-80 per cent and above 80 per cent) on each source. In Village I, of the 17 households in Class I, 13 households depend to less than 20 percent on purchased fuel and collected fuel (own land), but depend heavily on outside collections viz., 9 households depend more than 80 per cent and 5 households between 60-80 per cent. In the highest land class (Class V) dependence on purchased fuel and collected (outside) in all households is below 40 per cent (for 3 out of 5 households purchased fuel is below 20 per cent and 4 out of 5 households outside collection is below 20 per cent and more than 60 per cent of the total fuel requirements is met from one's own land.

In Village II the above trend of dependence is more pronounced (See Table 6.8). 5 households out of 6 in the lowest class depend on outside collections to an extent of 60 per cent or more with 3 households depending more than 80 per cent. In the highest class the dependence on collection from own land is almost total with all the households depending on it more than 80 per cent.

In Village III all the classes of households depend heavily on purchased fuel ranging from 60 per cent and above. There is no inter-class differences in the source of fuel or extent of dependence.

Because of the inflexible nature of energy requirements for cooking, per capita consumption of NCE does not show much variations across social classes in all the three villages. Table 6.10 gives the per household and per capita NCE consumption in all the three villages. In Village I it ranges from 9.65 kg. FWE/week to 10.39 Kg. FWE/week. In Village II except in the lowest class per capita NCE does not show much variations. In Village III also there is not much variation across the classes. In examining the data it is seen that generally per capita NCE rises gradually as the household move up in social classes. But in the classes where the average family size is comparatively large there is a dampening effect on per capita consumption possibly because of economics of scale.

When the three villages were considered separately as single units it is found that per capita consumption of NCE does not show much difference between Village I and Village II. Per capita consumption of NCE of village I is 9.88 Kg. FWE/week and for Village II - it is 10.96 Kg.FWE/week. But in the case of Village III it is only 6.02 Kg.FWE/week. This decrease in per capita NCE consumption could be due to the comparatively poor food consumption level of the village and the prevalence of eating out habits (See Tables 5.11 and 5.14) and the necessity for purchasing fuels for a price.

Another important point emerging out of this study is the economies of scale in the household NC energy consumption. In order to find out this, we have classified the households into two size classes of six members and below and above six members. Per capita consumption was computed for each size class for each village and tabulated in Table 6.11. Per capita consumption is much lower in the class with more than six members in all the three villages. The per capita consumption figures are only 66.1 per cent, 60.3 per cent and 64.2 per cent of the respective consumption figures of the other size class.

Lighting

All the three villages are electrified. The percentage of electrified households to the total number of households in the three villages ranges from 42 per cent to 56 per cent (for Village I and II it is 42 per cent and for Village III it is 56 per cent) (See Tables 5.16, 5.17 and 5.18). As expected, the percentage of electrified households increases with land/income classes. (All the households in the highest land class of Village I and II are electrified and in the highest income class of the third village 75 percent of the households are electrified). Per household consumption of electricity generally increases with land/income classes in all the three villages. The electrified households have a weekly consumption of about 4.8 KWH (std. units), 5.4 KWH and 4.3 KWH in the three villages respectively.

Conclusion

This chapter summarised the results of the study. By analysing the data collected from the sample villages we find that at the village level availability, source and types of NCE consumed are dynamically linked to the energy resource endowment of the village eco-system. Villagers tend to use whatever is accessible to them within the village system. The behaviour within the village varies with the social class the household belongs to. Ownership of fuel producing assets is unequally distributed within the village and as such the extent of use of different types of fuel materials by the different classes also varies showing a positive linkage between the two. Among the different classes, invariably the households in the lowest classes are the most hard pressed for domestic energy requirements. Since energy is a basic need for all households irrespective of the socio-economic class, even the poorest of the lowest class have to evolve ways and means to overcome the difficulty. But this 'tightness' with respect to energy is seen varying in degree depending on the particular eco-system. For some eco-system it is mitigated by a sort of 'resilience' in the system brought about by positive factors in the system like favourable resource endowment, access to exogenous resources free of cost, etc. Thus the households in the lower classes are able to manage their energy needs with less difficulty. But in an eco-system which is inherently deficient in energy resources it is the poorest classes that bear the greatest burden. A part of their earnings is set apart for procuring fuel. In Village I and II the 'resilience' described above is evident to a certain extent but in a Village III it is absent resulting in greater hardship to all especailly to the poorest.

As expected, per capita energy consumption does not show much variation across different classes. But there are indications of economies of scale in the household energy consumption. Consumption of energy for lighting is also analysed in this chapter.

Table 6.1: Energy from Different Types of Fuel Materials as a percentage of total NCE Consumption

Name of Village	Firewood	Coconut products	Others including agro-wastes
I Puliyur	62.03	32.53	5.45
II Kunnummel	42.63	45.37	12.00
III Puthiyathura	48.97	48.57	2.45
All Villages	51.2	41.4	7.4

Table 6.2.1: Consumption of Different Types of Fuels Across Land Classes: Village I (Puliyur)

in FWE Kgs (Per Week)

Land Class (acres)	No. of HHLDs	Fire wood	Coconut products	Others
0–0.10	17	578.62 (76.98)	148.18 (19.72)	24.82 (3.30)
0.10–0.50	9	327.98 (63.18)	138.62 (26.70)	52.54 (10.12)
0.51–1.00	9	264.02 (49.70)	245.90 (46.29)	21.30 (4.01)
1.01–2.50	8	252.0 (55.59)	183.63 (40.50)	17.77 (3.92)
Above 2.50	5	206.49 (55.65)	138.02 (37.19)	26.57 (7.16)
Total	–	1,629.10 (62.03)	854.35 (32.53)	143.01 (5.45)

Figures in parentheses give percentage

Table 6.2.2: Consumption of Different Types of Fuels Across Land Classes: Village II (Kunnummel)

in FWE Kgs (Per Week)

Land Class	No. of HHIDs	Fire wood	Coconut products	Others
(acres)				
00–0.10	6	97.50 (33.34)	124.16 (42.46)	70.74 (24.19)
0.11–0.50	10	188.85 (41.41)	206.87 (45.36)	60.36 (13.23)
0.51–1.00	14	293.45 (37.92)	399.71 (51.65)	80.72 (10.43)
1.01–2.50	12	338.61 (47.63)	290.20 (40.82)	82.11 (11.55)
Above 2.50	8	267.82 (48.77)	241.35 (43.95)	40.03 (7.29)
		1,186.23 (42.63)	1,262.29 (45.37)	333.96 (12.00)

(figures in parentheses give percentage)

Table 6.2.3: Consumption of Different Types of Fuels Across Ownership Classes: Village III (Puthiyathura)

in FWE Kgs (Per Week)

Ownership Class	No. of HHLDs	Fire Wood	Coconut products	Others
1	21	303.03 (41.64)	384.64 (52.86)	40.02 (5.5)
2	19	341.78 (54.07)	290.38 (45.93)	-
3	6	103.01 (46.05)	118.15 (52.82)	2.53 (1.13)
4	4	100.63 (67.53)	48.39 (32.47)	
Total		848.45 (48.97)	841.56 (48.57)	42.55 (2.45)

(figures in parentheses give percentage)

Table 6.3.1: Distribution of Major Fuel Producing Assets Across Land Classes of Village I (Puliyur)

Land Class (acres)	No. of HHLDs	Total garden land area of the class (acres)	Total number of cococnut trees	Total Number of big trees*
00 - 0.10	17 (35.4)	1.02 (2.6)	37 (2.9)	12 (5.0)
0.11 - 0.50	9 (18.8)	2.52 (6.5)	103 (8.2)	21 (8.8)
0.51 - 1.00	9 (18.8)	8.1 (20.7)	377 (30.1)	44 (18.4)
1.01-2.50	8 (16.7)	10.9 (28.0)	387 (31.1)	76 (31.8)
Above 2.50	5 (10.4)	16.5 (42.2)	349 (27.8)	86 (36.0)
Total	48 (100)	39.1 (100)	1,253 (100)	239 (100)
Per household	-	0.82	26	5

*Other than coconut tree and above 125 cm girth at B.H.

Figures in parentheses give percentage

Table 6.3.2: Distribution of Major Fuel Producing Assets Across Land Classes of Village II (Kunnummel)

Land Class (acres)	No. of HHLDs	Total garden land area of the class (acres)	Total number of coconut trees	Total Number of big trees*
.00-0.10	6 (12)	0.15 (0.3)	5 (.2)	4 (1.4)
0.11-0.50	10 (20)	3.66 (5.8)	159 (6.8)	19 (6.5)
0.51-1.00	14 (28)	11.69 (18.5)	458 (19.5)	51 (17.3)
1.01-2.50	12 (24)	19.81 (31.3)	752 (31.9)	96 (32.7)
Above 2.50	8 (16)	27.89 (44.1)	980 (41.6)	124 (42.2)
Total	50 (100)	63.2 (100)	2,354 (100)	294 (100)
Per household	-	1.26	46	6

*Other than coconut tree and above 125 cm girth at B.H.

Figures in parentheses give percentage

Table 6.3.3: Distribution of Major Fuel Producing Assets Across Ownership Classes of Village III (Puthiyathura)

Ownership Class	No. of HHLDs	Total garden land area of the class (acres)	Total number of coconut trees	Total number of big trees*
1	21 (42)	0.21	48	-
2	19 (38)	0.57	63	-
3	6 (12)	0.18	41	-
4	4 (8)	0.08	7	-
Total	50 (100)	1.04 (100)	159 (100)	-
Per Household	-	0.02	3	-

*Othern than coconut tree and above 125 cm girth at B.H.

Figures in parentheses give percentage

Table 6.4.1.A: Contributions from Different Sources of Fuel Across Social Classes in Village I (Puliyur)

in FWE kgs. (Per week)

Land Class (acres)	Purchased	Collected (own land)	Collected (outside)	Total
0.0–0.10	105.5 (38.0)	81.5 (6.8)	566.1 (49.4)	753.1
0.11-0.50	46.3 (16.6)	158.7 (13.2)	314.2 (27.4)	519.2
0.51-1.00	44.5 (16.0)	374.3 (31.1)	112.4 (9.8)	531.2
1.01-2.50	18.0 (6.5)	303.0 (25.2)	132.5 (11.6)	453.5
Above 2.50	63.5 (22.9)	286.6 (23.8)	21.0 (1.8)	371.1
Total	277.8 (100)	1,204.1 (100)	1,146.2 (100)	2,628.1

Figures in paranthesés give percentage

Table 6.4.1.B: Contributions from Different Sources of Fuel Across Social Classes in Village II (Kunnummel)

in FWE Kgs. (Per week)

Land Class (acres)	Purchased	Collected (own land)	Collected (outside)	Total
0.00-0.10	60.3 (31.2)	18.2 (0.9)	212.9 (45.5)	291.4
0.11-0.50	34.9 (18.1)	342.2 (16.1)	79.5 (17.2)	456.6
0.51-1.00	50.9 (26.4)	593.7 (28.0)	129.2 (27.6)	773.8
1.01-2.50	47.0 (24.3)	618.4 (29.1)	45.6 (9.8)	711.0
Above 2.50	-	549.8 (25.9)	-	549.8
Total	193.2 (100)	2,122.3 (100)	468.3 (100)	2,782.6

Figures in parentheses give percentage

Table 6.4.1.C: Contributions from Different Sources of Fuel Across Social Classes in Village III (Puthiyathura)

in FWE Kgs.(Per week)

Ownership Class	Purchased	Collected (own land)	Collected (outside)	Total
1	634.5 (41.5)	39.6 (32.2)	56.9 (67.7)	731.0
2	567.7 (37.2)	43.2 (35.1)	21.5 (25.6)	632.4
3	183.6 (12.0)	37.0 (30.1)	3.1 (3.7)	223.7
4	141.7 (9.3)	3.2 (2.6)	2.5 (3.0)	147.4
Total	1,527.6 (100)	123.0 (100)	84.0 (100)	1,734.5

Figures in parentheses give percentage

Table 6.4.2.A: Contributions from Different Sources of Fuel Across Social Classes in Village I (Puliyur)

in FWE Kgs. (per week)

Land Class (acres)	Purchased	Collected (own land)	Collected (outside)	Total
0.00-0.10	105.5 (14.0)	81.5 (10.8)	566.1 (75.2)	753.1 (100)
0.11-0.50	46.3 (8.9)	158.7 (30.6)	314.2 (60.5)	519.2 (100)
0.51-1.00	44.5 (8.4)	374.3 (70.5)	112.4 (21.2)	532.2 (100)
1.01-2.50	18.0 (4.0)	303.0 (66.8)	132.5 (29.2)	453.5 (100)
Above 2.50	63.5 (17.1)	286.6 (77.2)	21.0 (5.7)	371.1 (100)
Total	277.3 (10.6)	1,204.1 (45.8)	1,146.2 (43.6)	2,628.1 (100)

Figures in parentheses give percentage

Table 6.4.2.B: Contributions from Different Sources of Fuel Across Social Classes in Village II (Kunnummel)

in FWE Kgs. (per week)

Land Class (acres)	Purchased	Collected (own land)	Collected (outside)	Total
0.00-0.10	60.3 (20.7)	18.2 (6.3)	212.9 (73.1)	291.4 (100)
0.11-0.50	34.9 (7.7)	342.2 (74.9)	79.5 (17.4)	456.6 (100)
0.51-1.00	50.9 (6.6)	593.7 (76.7)	129.2 (16.7)	773.8 (100)
1.01-2.50	47.0 (6.6)	618.4 (87.0)	45.6 (6.4)	711.0 (100)
Above 2.50	-	549.8 (100)	-	549.8 (100)
Total	193.2 (6.9)	2,122.3 (76.2)	468.3 (16.8)	2,783.6 (100)

Figures in parentheses give percentage

Table 6.4.2.C: Contributions from Different Sources of Fuel Across Social Classes in Village III (Puthiyathura)

in FWE Kgs. (per week)

Ownership Class	Purchased	Collected (own land)	Collected (outside)	Total
1	634.5 (86.8)	39.6 (5.4)	56.9 (7.8)	731.0 (100)
2	567.7 (89.8)	43.2 (6.8)	21.5 (3.4)	632.4 (100)
3	183.6 (82.0)	37.0 (16.5)	3.1 (1.4)	223.7 (100)
4	141.7 (96.2)	3.2 (2.2)	2.5 (1.7)	147.4 (100)
Total	1,527.6 (88.1)	123.0 (7.1)	84.0 (4.8)	1,734.5 (100)

Figures in parentheses give percentage

Table 6.5: Sources of Different Types of Fuel in the Sample Villages

in FWE Kgs (per week)

Village	Firewood			Coconut Products			Others		
	Purchased	Collected (own land)	Collected (outside)	Purchased	Collected (own land)	Collected (outside)	Purchased	Collected (own land)	Collected (outside)
I Puliyur	227 (13.9)	379 (23.2)	1,026 (62.9)	48 (5.6)	714 (83.7)	91 (10.7)	3 (1.8)	112 (77.7)	30 (20.6)
II Kunnummel	162 (13.7)	766 (64.6)	258 (21.7)	31 (2.4)	1,101 (87.2)	131 (10.4)	- -	256 (76.3)	79 (23.7)
III Puthiyathura	842 (99.9)	-	1 (.1)	656 (77.9)	118 (14.0)	69 (8.2)	30 (59.6)	5 (10.8)	15 (29.6)

Table 6.6: Monthly Expenditure on NC Energy of Different Ownership Classes (Puthiyathura)

Ownership Class	Number of HHLDs	Average monthly income (Rs.)	Expenditure on NCR (monthly)
1	21	263.10	64.75 (24.6)
2	19	281.32	64.03 (22.75)
3	6	526.67	65.48 (12.45)
4	4	827.5	75.93 (9.18)
All	50	346.8	65.45 (18.87)

Table 6.7: Extent of Dependence of Households on Different Sources of Fuel: Village I (Puliyur)

Land Class (acres)	No. of HHLDs	Dependence on purchased fuel (No. of Households)					Dependence on collected fuel (own land) No. of HHLDs					Dependence on collected fuel (outside) No.of Households)				
		0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%
.00-0.10	17	13	3	0	0	1	13	4	0	0	0	1	0	2	5	9
0.11-0.50	9	8	0	1	0	0	2	4	3	0	0	0	0	4	5	0
0.51-1.00	9	8	0	1	0	0	0	1	2	2	4	5	2	1	1	0
1.01-2.50	8	7	1	0	0	0	0	0	4	2	2	3	2	3	0	0
Above 2.50	5	3	2	0	0	0	0	0	0	3	2	4	1	0	0	0

Table 6.8: Extent of Dependence of Households on Different Sources of Fuel: Village II (Kunnummel)

Land Class (acres)	No. of HHLDs	Dependence on purchased fuel (No. of HHLDs)					Dependence on collected fuel (own land) No. of HHLDs					Dependence on collected fuel (outside) No. of HHLDs				
		0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%
0.00-0.10	6	3	2	1	0	0	6	0	0	0	0	0	0	1	2	3
0.11-0.50	10	8	2	0	0	0	0	0	2	4	4	6	2	2	0	0
0.51-1.00	14	12	1	1	0	0	0	0	4	4	6	8	3	3	0	0
1.01-2.50	12	11	0	1	0	0	0	1	1	0	10	11	0	0	1	0
Above 2.50	8	8	0	0	0	0	0	0	0	0	8	8	0	0	0	0

Table 6.9: Extent of Dependence of Households on Different Sources of Fuel: Village III (Puthiyathura)

Ownership Class	No. of HHLDs	Dependence on purchased fuel (No. of HHLDs)					Dependence on Collected fuel (own land) No. of HHLDs					Dependence on collected fuel (outside) No. of HHLDs				
		0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%	0-20%	20-40%	40-60%	60-80%	above 80%
1	21	0	0	0	5	16	19	2	0	0	0	19	2	0	0	0
2	19	0	0	0	2	17	17	2	0	0	0	19	0	0	0	0
3	6	0	0	0	3	3	3	3	0	0	0	6	0	0	0	0
4	4	0	0	0	0	4	4	0	0	0	0	4	0	0	0	0

Table 6.10: Per Household and Per Capita NCE Consumption of Different Classes

(in FWE Kgs.) (Per week)

	Puliyur		Kunnummel			Puthiyathura		
Land Class	Per Household consumption	Per Capita consumption	Land Class	Per HHLD Consumption	Per Capita Consumption	Ownership Class	Per HHLD Consumption	Per Capita Consumption
(acres)								
0.00-0.10	44.25	9.65	0.00-0.10	48.78	8.73	1	34.65	5.68
0.11-0.50	57.69	9.62	0.11-0.50	45.65	10.61	2	33.29	6.14
0.51-1.00	59.02	9.49	0.51-1.00	55.28	11.05	3	37.28	6.40
1.01-2.50	56.68	10.80	1.01-2.50	59.24	11.65	4	37.27	6.78
Above 2.50	74.22	10.39	above 2.50	68.70	12.21			
All Classes	54.73	9.88	All classes	55.67	10.96	All classes	34.69	6.02

Table 6.11: Per Capita Consumption of NCE Across Family Size Classes

in FWE Kgs (Per Week)

Puliyur			Kunnummel			Puthiyathura		
Size Class	Number of Households	Per Capita Consumption	Size Class	Number of Households	Per Capita Consumption	Size Class	Number of Households	Per Capita consumption
1-6	39	11.27	1-6	40	13.2	1-6	30	7.46
Above 6	9	7.46	Above 6	10	7.97	Above 6	20	4.80

FIG.3: TYPES OF FUEL MATERIALS CONSUMED IN VILLAGES

(ALL VILLAGES CONSIDERED)

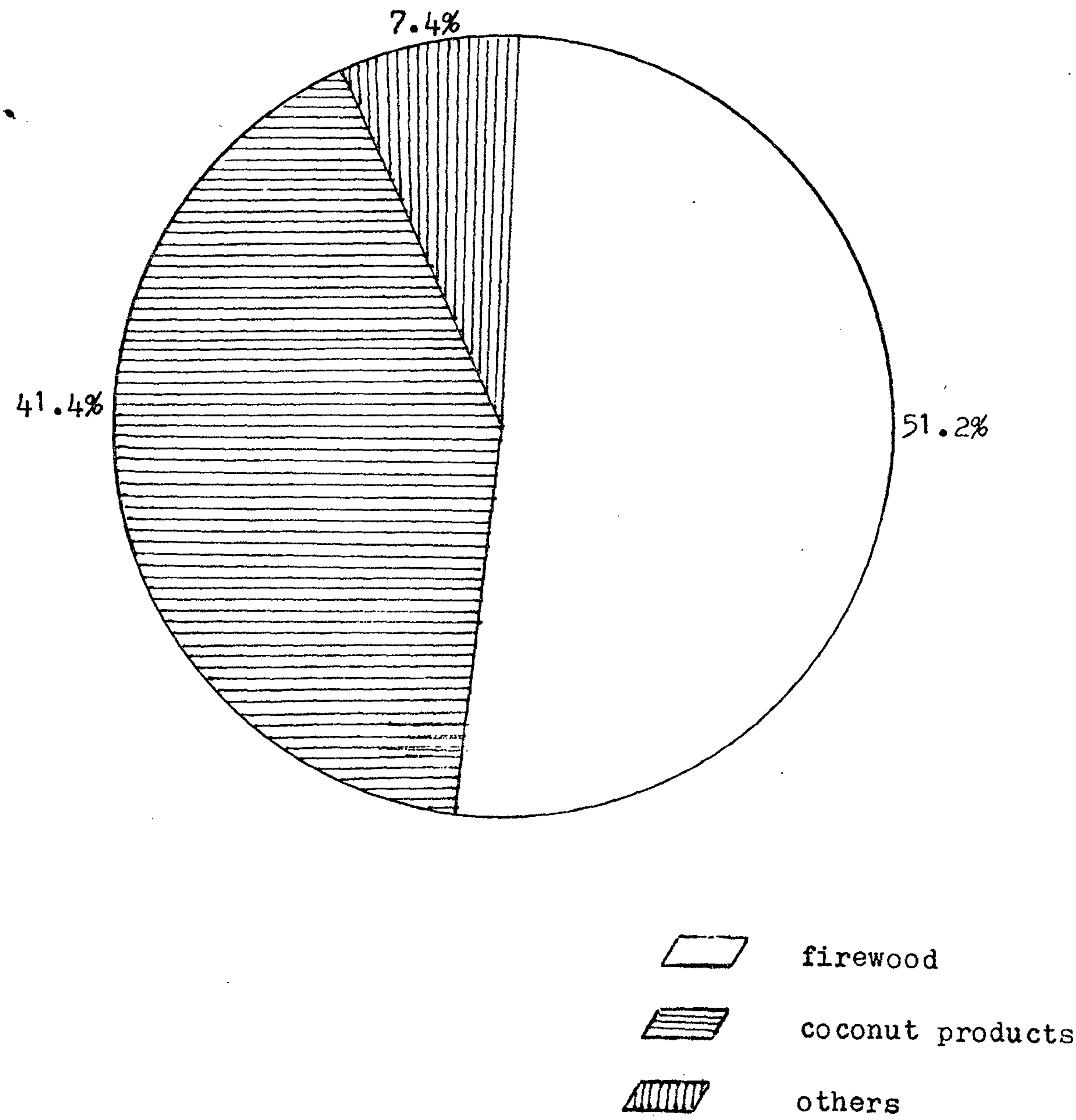


FIG.4: TYPES OF FUEL MATERIALS CONSUMED IN VILLAGES

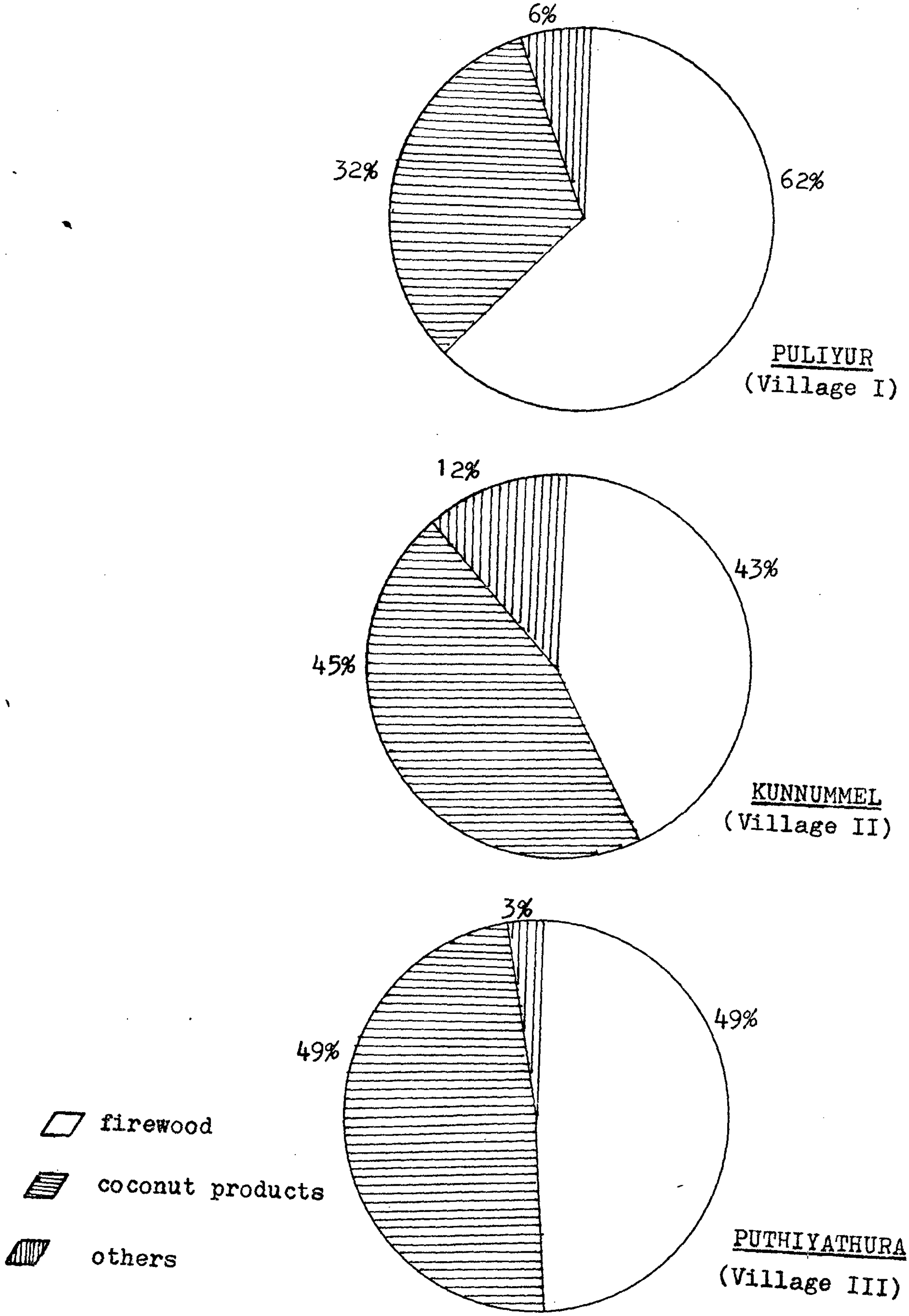


FIG.5: DEPENDENCY ON DIFFERENT TYPES OF FUEL MATERIALS ACROSS SOCIAL CLASSES

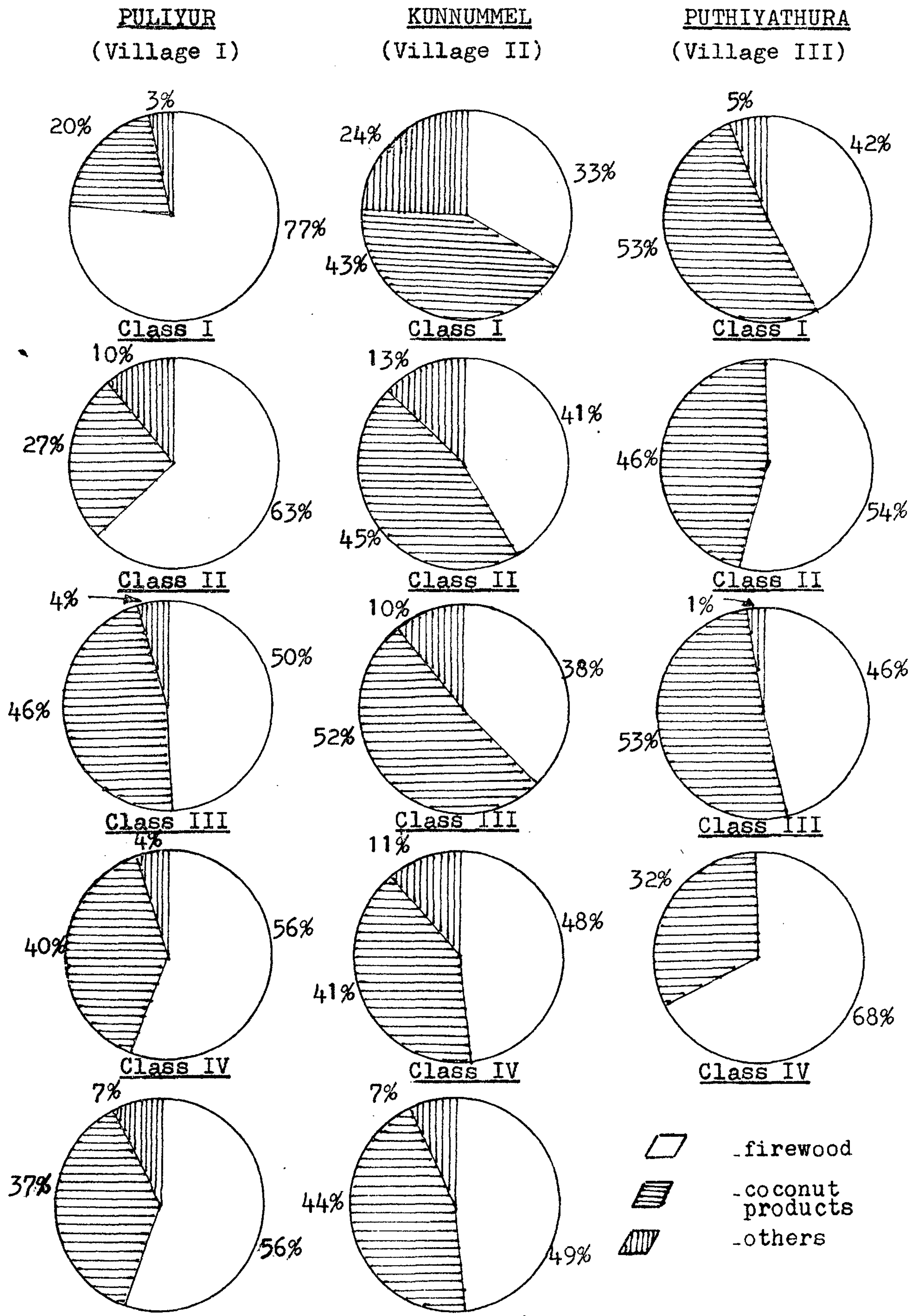


FIG.6: SOURCES OF FUEL AND THEIR CONTRIBUTIONS

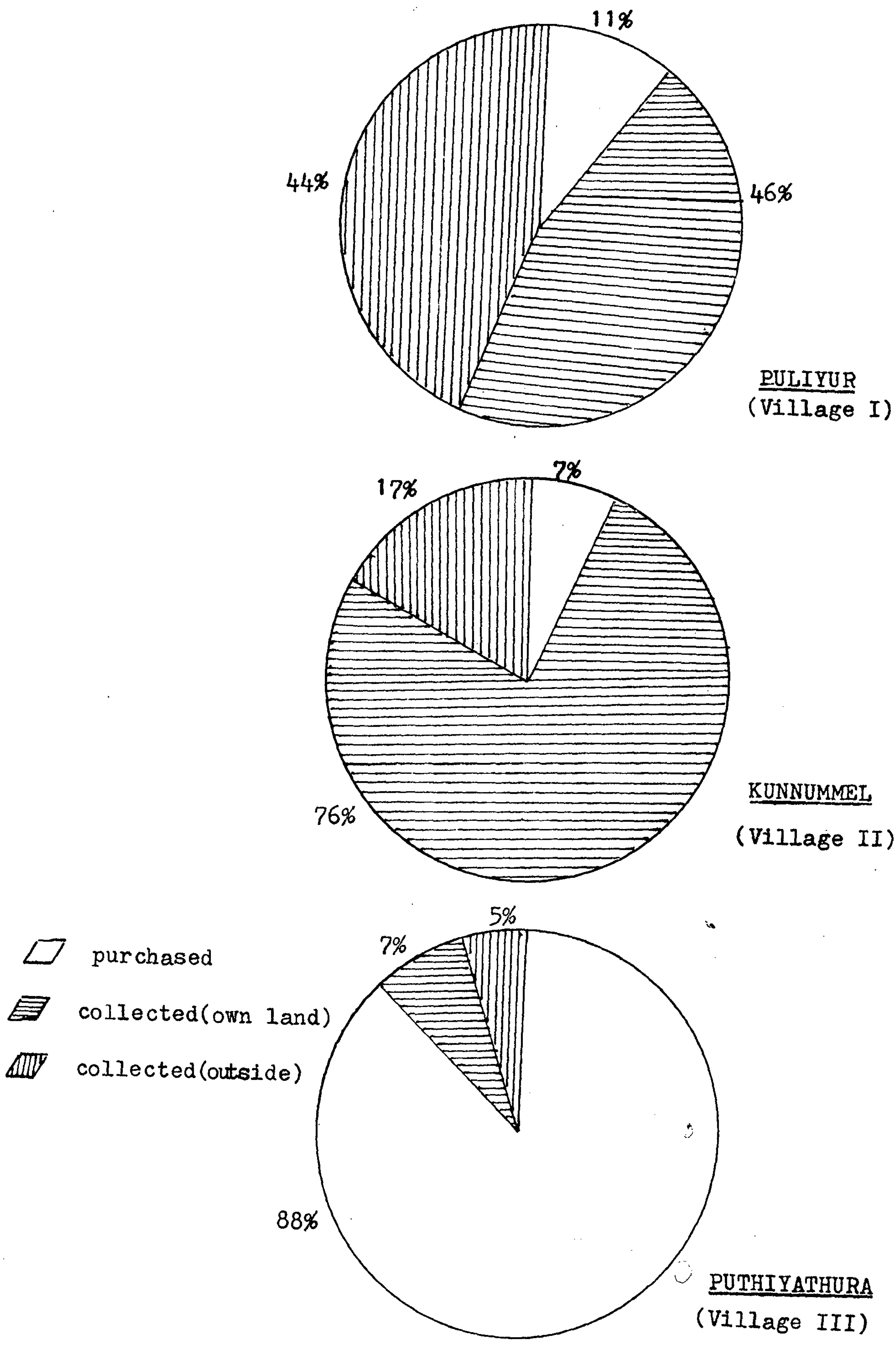
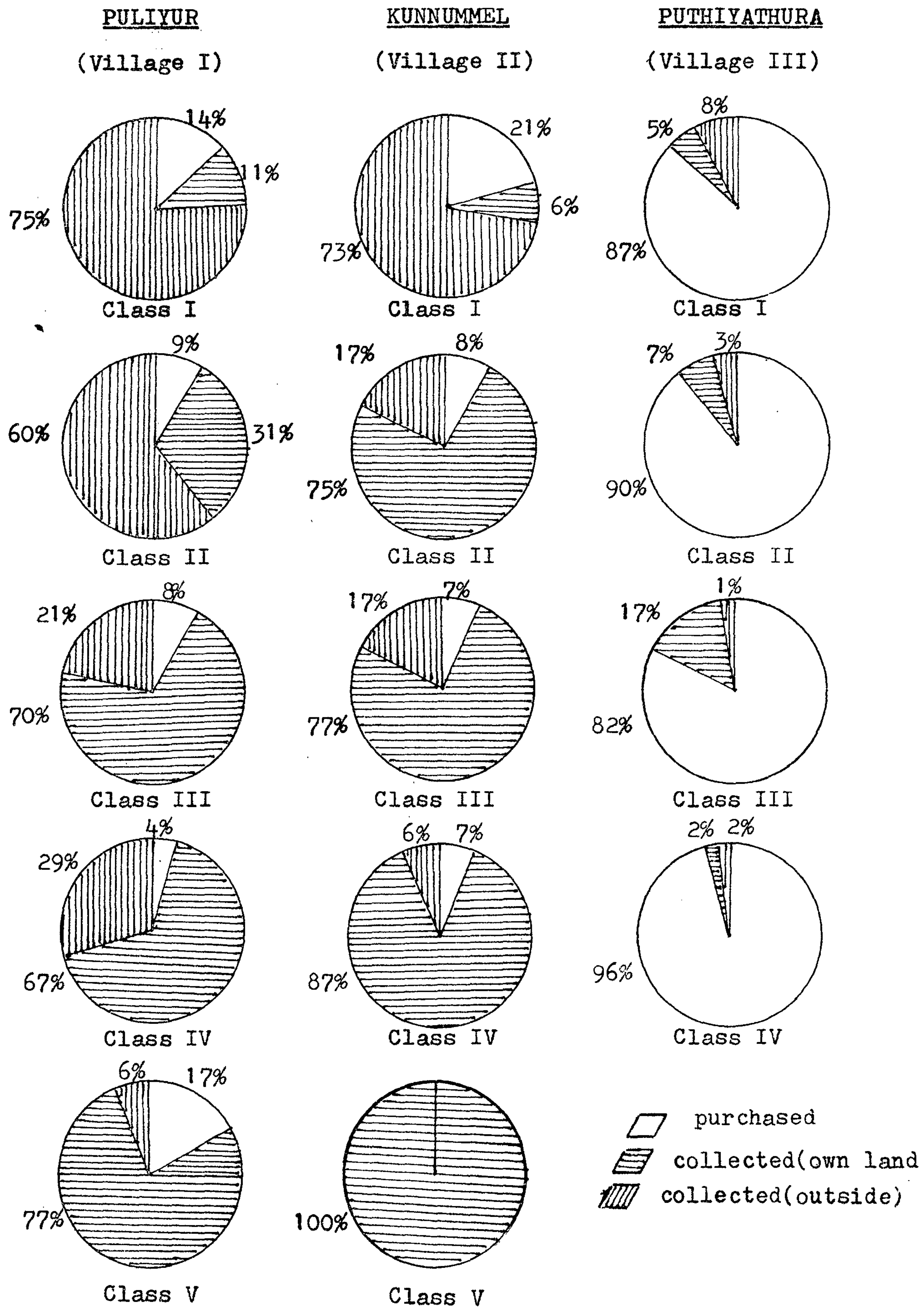


FIG.7: DEPENDENCY ON DIFFERENT SOURCES OF FUEL ACROSS SOCIAL CLASSES



Chapter VII

Concluding Observations

Household energy consumption in rural areas is one of the least understood aspects of the economy in India. A few studies at the macro level which though useful in many respects are inadequate to understand fully the complex and systemic linkages. Since non-commercial energy resources which is used predominantly in rural areas, are available locally and are of biological origin the consumption pattern cannot be understood except in the context of eco-agricultural and socio-economic environment in which they are a part. A few isolated studies have thrown light on the pattern of household energy consumption in some regions of the country. But no study has been done for rural Kerala which is eco-agriculturally different from other regions with abundant biomass resources resulting from a tropical wet climate. It is generally believed that the domestic energy consumption pattern will be different from other regions of the country. Our purpose in this study is mainly to estimate the quantity, type and source of energy used for a typical eco-system, and how system characteristics in the villages influence the consumption or, in other-words, how system characteristics are manifested themselves in the energy consumption pattern. An aspect specifically of interest to us is the extent and form of dependence on coconut for domestic energy needs - a phenomenon endemic to Kerala.

For the purpose of our study we have selected three villages each representing the major ecological zone having distinct resource endowment and geographical features. 50 households were selected, in each village applying cluster sampling method. The methodology and scheme of survey followed in this study is a major departure from other energy consumption surveys conducted in India. NCE being available in a variety of forms and from numerous sources, respondents do not have a good idea of the exact quantity of consumption in terms of a standard unit of measurement. So we felt that 'recall' method followed in other surveys alone would lead to significant errors in estimate. To avoid this in our survey the fuel materials were weighed using balances for every day to know one week's consumption. Given the circumstances and nature of survey we selected the educated unemployed persons belonging to each village as our investigators. They were mostly women.

For the purpose of household energy consumption, sample villages generally were found to be closed systems. Villagers use what is easily available to them. Because of this there is a close relation between the energy resource endowment (aggregate of fuel producing assets) and types and sources of energy consumed by villagers. Consumption patterns in Village I and II confirm this.

But in an eco-system which is deficient in resources, villagers have to depend on energy imported from outside the village through markets. Village III is a typical example of a village deficient in resources. An important point emerging out of this study is the dependence on coconut trees for domestic energy needs - namely to the extent of 42 percent when all the villages are considered. This is an unique feature of Kerala which underlines the important linkage of a particular land utilisation pattern in the energy situation of a region. Coconut not only occupies the pivotal role in the agricultural economy of Kerala but plays a significant part in the energy economy also. If the domestic energy crisis prevalent in other regions of the country is not manifested in Kerala, it is due to this unique situation.

The behaviour of households in an apparently homogenous eco-system is far from uniform in respect of the types, sources and consumption of energy. To assess the influence of the socio-economic characteristics in the consumption pattern we have analysed the data at a disaggregated level in each village based on land holdings in the case of two villages and ownership of means of production in the case of the coastal village. Like many other economic assets in the rural economy, fuel producing assets namely, land, coconut trees and other trees are distributed unequally. The relative self-sufficiency of energy is contingent on this unequal distribution of fuel producing assets. Whereas the households in the higher land classes generally manage to meet the requirements of energy from home grown fuels, the households in the lowest classes are invariably hardpressed for meeting the energy requirements irrespective of the resource position of the village as a whole. The difficulty in procuring fuel is seen varying in degree depending on the particular eco-system - either they have to spend money to purchase fuels or take the trouble of collecting from nearby forests or private areas legally or illegally. The coastal village with unfavourable resource position depends very heavily on purchased fuel spending a substantial portion of their earnings (about 18 percent of their earnings). The magnitude of the problem is evident especially in view of the widespread malnutrition existing in coastal villages.

The crucial issue brought about by the study is the aspect of distribution of energy resource within a village. We find that consumption of domestic energy is influenced by the systemic characteristics. So when any intervention is considered in the rural energy system it cannot be done treating it as an isolated natural or technical problem but only in an overall developmental context, which is a historical and socio-structural phenomenon. In this context the formulation of the rural energy problem is critical. Majority of energy planning exercises in the country are guilty of decontextualising the energy problem. Legitimacy in rural energy planning is created by exclusive appeal to expert, quantitative knowledge like historical trends, econometric models and forecasting and suggesting incremental solutions. Strategic planning for rural energy should consider the linkages rural energy system has with systemic characteristics and what is ideally needed is measures for fundamental structural changes not just ad hoc measures. These issues although beyond the scope of our study are central to rural energy planning and adequate attention is warranted.

Domestic energy is a basic need for all irrespective of the social or economic class. This aspect has been adequately proved in our study also. The per capita energy consumption does not show much variation across classes. The relative difficulty in procuring energy for domestic needs is seen increasing with decreasing fuel producing assets which is positively correlated to distribution of land holdings. It is important at this juncture, to determine whether there is an 'household energy crisis' as is existing in other states of India. For example in the few villages studied in Karnataka State only about 19 per cent of total NCE is procured from consumer's own land and 47.5 per cent is gathered from outside. For this every household has to make, on an average, one trip every 2.5 days travelling 5.4 kms for the round trip. The firewood gathering household spends about 2.2 hours per day for collection. In the sample villages studied in Kerala about 48 per cent is procured from one's own land and only 24 per cent is gathered from outside (from the nearby forests or private lands). From observations it is found that villagers do not make regular trips nor they spend much time for collection of firewood. Thus from the limited data available from our study we find that the domestic energy problem is not as acute as in other regions of the country perhaps due of the historically evolved intensive land-utilisation pattern, having extensive areas under coconut plantation and abundant biomass resources resulting from a wet tropical climate. But in every village the poorest households are the hardest hit. However, to a certain extent, the poorest households in Village I and II are able to procure fuel for cooking because of the favourable resource conditions existing. But Village III (coastal village) is a classic example of resource deficient village and consequent difficulties in procuring fuels. The extent of dependence on purchased fuel (about 88%) in this village is of crucial significance. A part of their income (on an average about 18%) is exchanged for fuel and this aspect is quite significant especially in the context of the low level consumption of food and other essential goods in coastal villages.

As we can see from the above discussion the problem of domestic energy is an interaction of natural and social factors. It can be addressed only in an overall developmental context which is a socio-structural phenomenon. So the formulation of the problem is critical for effective policy intervention. For long term effects policy measures seeking fundamental structural changes are required. But, as short-term measures, deliberate planning options having positive bias towards the poorest sections of the society, are called for.

Notes

1. See, National Council of Applied Economic Research, Domestic Fuels in India, New Delhi, (1959)

2. The distinction between commercial and non-commercial fuels, though commonly accepted in literature, is not entirely satisfactory. The identification of so-called commercial fuels like petroleum products, coal, gas and electricity is straight forward. But the so-called non-commercial fuels (most of them of biological origin) are increasingly being brought and sold in organised markets. Therefore the distinction between commercial and non-commercial fuels, in the strict sense of the usage, is very blurred. Because of their widespread acceptance we also use them. But there is urgent need for a new terminology which reflects more realistically the spectrum of conditions under which these fuels are traded.

3. For example, see, ASTRA, Rural Energy Consumption Patterns - A Field Study, Indian Institute of Science, Bangalore, (1979) (Mimeo)

4. Revelle, R; "Energy Options for the Third World", in Norman Brown (ed), Renewable Energy Sources and Rural Application in the Developing World, AAAS Selected Symposium, (1978).

5. Earl, D.E; Forest Energy and Economic Development, Clarendon Press, Oxford, (1975).

6. Earl, D.R; op.cit.

7. Revelle.R; 'Energy use in Rural India' Science Vol.192 (1976).

8. For our purpose we are not considering the energy from wind, sun and such other new and renewable energy sources because of their very low consumption at present.

9. Btu - (British Thermal Unit) is equal to the heat required to raise the temperature of 1 pound of air-free water from 60° to 61° F. K.Cal - One Kilo calorie is equal to 1000 calories.
Ton-il-equivalent - One toe is defined as 10,000 K.cal. roughtly the heat content of a metric tonne of crude oil

10. a. Report of the Energy Survey Committee, Government of India (1965)
b. Report of the Fuel Policy Committee, Government of India (1974).
c. Report of the Working Group on Energy Policy (1979)

11. Reddy, A.K.N.; 'Alternate Energy Policies for developing countries; A Case Study of India' (mimeo).

12. Although the importance of animal energy is mentioned in the policy oriented reports, no attempt to analyse the pattern or compute reliable estimates is done because of inadequate data.

13. See; John Dunkenly, "Domestic Energy Consumption by the poor in developing countries" in Pachauri, R.K. (ed), International Energy Studies Wiley Eastern Ltd. (1980).

14. For a detailed discussion see; Asok V.Desai; Energy output and consumption in India - A Methodological review, Working Paper No.97, Centre for Development Studies, Trivandrun 1979.

15. See Revelle, R; (1976) op.cit.

16. Henderson; "India: The Energy Sector", Oxford University Press, 1973

17. Henderson; ibid

18. Reddy, A.K.N.; op.cit.

19. NSS estimates (28th Round) as quoted in the Report of the Working Group on Energy Policy (1979).

20. Ashok V. Desai, op.cit.

21. Ashok V. Desai, op.cit.

22. John Briscoe; 'Energy use and Social Structure in a Bangladesh Village'; Population and Development, Vol.5, 1979, p.615.

23. ASTRA; "Rural Energy Consumption Patterns - A field Study" Astra, Bangalore (1980).

24. Milhayi, L.J.; "On the Investigation into the Nature, Economic and Social significance of the Charcoal Industry in Zambia" quoted in Peter Hayes: "Social Structure and Rural Energy Technology", Southern Perspectives on Rural Energy Crisis (August 1981) Nautilis.

25. Bajracharya, D; "Firewood and Food Need versus Deforestation: An energy study of a Hill village Panchayat in Eastern Nepal" Resource Syste m Institute, Hawai 1980 as quoted in Peter Hayes; op.cit.

26. A Scheme for housing the weakest sections under a programme of constructioning one lakh houses for the state as a whole initiated in 1972.

27. Some qualities of rice require such more energy and time for cooking than some others.

28. One unique feature of the local market here is that it is equipped to meet the allround fuel shortage in coastal areas. It is a common feature throughout village markets in Kerala that villagers come to the market with home grown agricultural products like coconut, jackfruit, mangoes, pineapples etc. and sell them to purchase their daily fish, vegetables and other things. But it is rare that people from nearby villages come with firewood or coconut fuel materials to sell them in markets to purchase their daily requirements, as they do in this village.

The reason for this could be the high demand for firewood from coastal villagers and the good price they get for it (about 50 ps. per kilogram).

29. The preference for firewood to coconut products can be due to a number of reasons like.

    i. It generates less smoke

    ii. Higher calorific value

    iii. Density of wood being higher it will not burn out quickly and thus less attention is needed while cooking.

    iv. Easy to store.

Appendix I

Problems in Estimating Animate Energy

Estimation of human energy involves a number of assumption and approximations which are not backed by scientific and reliable studies. Precisely for this reason most of the studies on rural energy ignore this. As in many developing countries, in India also, human energy constitutes one of the major sources of energy for rural communities in agriculture, transport and household economic activities. Since the same work can be done by machines using other forms of energy it is impossible to study the consumption of say coal, oil or electricity without recognising that a significant portion of these fuels partially or actually replaces human energy. Human energy has been studied by various research workers in several different methods and with widely differing results. Piemental[a/] take the total intake of food energy input of a full-time farm worker as a measure of energy utilised in the farm sector. Makhijani & Poole[b/] use the energy in the food intake of all persons in a farming village as the gross energy inputs for human labour. Taking hypothetical example of a village he estimates the gross energy input by simple multiplication of per capita food intake by the

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a. Piemental (et.al), as quoted in Revelle, R.(1976)

b. Makhijani and Poole: Energy and Agriculture in Third World, Balinger Pub.Co., Cambridge, (1975).

number of people in a village. After considering the annual per capita work output he estimates the 'energetic efficiency' as 3 percentage for all human beings in the village. Passmore and Durnin[c] estimate the metabolic energy used in different work activities from measurements of Oxygen consumed and carbondioxide exhaled. Revelle[d] in his estimate of Indian rural energy consumption estimates the energy per hour expended in work from data given for various tasks by Passmore and Durnin to arrive at the conclusion that the ratio of gross work done to calorie intake for Indians is in the range of 8.75 - 11 per cent. Desai[e] using some relevant physiological studies for human beings calculates the maximum efficiency at which food consumption can be converted into work at the nutritional levels prevelant in India to be around 9 per cent.

In examining the estimates one finds wide variations depending on the assumptions. Estimates are difficult to make because of problems like which form of energy to be counted (Primary energy or final energy or useful energy)[f] in estimating energy actually expended in work,

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c. Passmore and Durmin as quoted in Revelle, R; op.cit.

d. Revelle, R; op.cit.

e. Asok V.Desai, Energy Output and Consumption in India: A Methodological Review, Working Paper No.97, Centre for Development Studies 1979.

f. Primary energy = Energy obtained from natural resources

Final energy = Energy which is delivered to the consumers after distribution losses.

Useful Energy = Efficiency of use X final energy.

whether the whole population or only the working population has to be taken into account, whether all energy consuming activities to be included or only part of it, what is the minimum metabolic energy needed, the long-term relationship between food intake and work capacity, etc. etc. Even with all these difficulties it is important that the contribution of human energy should not be lost sight of while considering specific energy uses like use of energy in Agriculture or Transport sector.

It is less easy to determine the proper way to account for energy expended in bullock work and the underlying data are less adequate. While the physiological models for animals would not be much different from that of human beings its parameters would obviously be different and we have no reliable data base. Odend'hal[g/] considers bullock as a kind of working machine. The energy in its 'manufacture' might be included in the accounting - that is, net energy input (feed energy minus dung) of the cattle population less the energy in milk and other products. Alternatively the energy consumed annually in feed by the bullock itself minus the energy in its dung divided by the number of hours worked could be taken as its gross energy expenditure per working hour. (Harris (1966)). Revelle (1976) used a third method which gives smaller values and assumes that a fully employed bullock utilises about 45 per cent of

g. Odend'hal.S; 'Energetics of India Cattle in their environment' Human Ecology 1, 3-32 (1972).

energy it consumes in work. The method used by Odend'hal gives 12.1×10^3 k cals per hour of work, while the second method gives 5.3×10^3 k cals and the method used by Revelle gives 2.3×10^3 k.cals.

As discussed in Chapter II we do not have reliable estimates even on fodder consumption of working animals, without which it is difficult to estimate dung production from fodder-dung conversion factors. Animal energy estimations are, thus, difficult and estimates can very widely depending on the assumptions made.

In India there are 80 million working animals [Report of the Working Group on Energy Policy (1979)] and about 13 million animal drawn carts. Bullock work, mostly used in rural areas (Revelle assumes that to be about 83 per cent) in ploughing, cultivating, irrigating fields, harvesting and rural transport accounts for a substantial part of rural energy system. A.R. Rao and J.Singh[h/] assume 0.5 hp to be the animal power per animal and estimate that 42.5 million hp is available from animal power alone which is equivalent of 30,000 MW of electricity. But these are crude estimates and one should be cautions in using them. Only when we have data on sectorwise use of animal energy, type of design of carts employed, number of days on which it is profitably employed, income derived, nature of freight, pattern of ownership

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h. Rao, A.A. and Singh I.J; "Choice of foods to shorter food chains in India" in William Lockretz (ed), Agriculture and Energy, Academic Press (1976).

etc., we can understand with a certain amount of confidence the contribution of animal energy in the overall energy system of the economy. This calls for systematic studies on animal energy consumption.

Appendix II

Determination of Calorific Values of Different Fuel Materials

The households in the villages studied use a variety of NCE materials which differ in calorific values. Broadly they comrpise of the following.

i. Firewood

ii. Coconut leaves

iii. Coconut cadjan (leaf stem)

iv. Coconut husk

v. Coconut shell

vi. Coconut inflorescenee sheath

vii. Other coconut materials like roots, inflorescene, etc.

viii. Agrowastes (mostly tapioca stems)

ix. Others (saw dust, tree leaves, etc.)

For purposes of understanding the level of production and consumption, the different forms have to be aggregated using a common unit of measurement. Standard values are available for certain forms like firewood, kerosene, electricity, etc. But for most of the coconut products calorific values are not available. So we have designed a simple experiment to find out the comparative heat value of the different fuel materials keeping firewood as a standard. The fuel materials used in the experiment were in 'as used' condition to reflect field situations and not on a dry basis. Of the nine types of fuel materials listed earlier only the first eight were analysed for comparative heat values. The last type was not analysed because it comes in a variety of forms ranging widely in calorific values. So it was treated as equivalent to firewood. The experiment was conducted in a clay type closed chulah ordinarily available in markets.

Experiment

A weighed quantity of fuel was burned carefully to heat a known quantity of water in an aluminium vessel with a wooden lid. A thermometer passing through the hole in the lid of the vessel recorded the initial and subsequent changes in temperature of water every minute over a period of time till it showed the maximum temperature. The decrease in temperature from maximum was also recorded every minute till a drop of 8–10°C was noticed. The unburned fuel and charcoal, if any, were taken out and weighed to know the exact quantity of fuel used. The final weight of water was also recorded to find out the loss of water through evaporation. A time-temperature graph was plotted on a graph paper and the cooling correction to be applied was calculated. The calorific value was determined from the following equations.

Total heat input = Heat input due to temperature rise + Heat input for evaporation of water.

Heat input due to temperature rise = [(Specific heat of Al_3 x Weight of vessel in grams) + (Weight of water in grams)] (Maximum temperature - Initial temperature) + Cooling correction in °C

Heat input for evaporation of water = Weight of Water lost in evaporation in grams (latent heat of evaporation of water + (100 - Initial temperature))

$$\text{Calorific Value} = \frac{\text{Total heat input}}{\text{Fuel consumed in grams}}$$

The calorific value thus obtained is not the exact calorific value of the fuel used. It is a combined value incorporating the efficiency of the stove used and efficiency of burning. For our purposes we are not finding out the exact calorific values of fuels but only determining the comparative heat values of different types of fuel by keeping firewood as a standard (calorific value of firewood is already available in any standard book on the subject). For each type of fuel the experiment was run for a number of times to get constant values. The comparative heat values (Firewood equivalents (FWE)) obtained for different types of fuel are given below.

i. Firewood 1 kg = 1 FWE kg

ii. Coconut leaves 1 kg = 1.2 FWE kg

iii. Coconut cadjan (leaf stem) 1 kg = 0.77 FWE kg

iv. Coconut husk 1 kg		= 0.45 FWE kg
v. Coconut shell 1 kg		= 1.23 FWE kg
vi. Coconut inflorescence sheath	1 kg	= 0.98 FWE kg
vii. Other coconut materials	1 kg	= 0.85 FWE kg
viii. Agrowastes	1 kg	= 0.76 FWE kg.

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