INDIAN JOURNAL OF RURAL TECHNOLOGY

VOL 1, 1989

EDITOR
ASHA JOGLEKAR

ASSISTANT EDITOR
MANJU SAKSENA

CAPART

Design & Produced by GRAFIK CELL, A-1/87 SJE New Delhi–29
Printed by Bankers Press, New Delhi

Ind J Rural Technol **1** *(1989) 33-63*

Energy Utilisation Pattern of Shilarwadi*

Anil Date

Centre for Technology Alternatives for Rural Areas
Indian Institute of Technology, Bombay, Powai 400076, India

(Received 15 April 1988; accepted 11 April 1989)

The energy consumption/utilisation pattern was determined for a hamlet, Shilarwadi, situated 120 km north-east of Bombay in Karjat Taluk of Raigarh Dist. of Maharashtra. Detailed notes of activities and assets of the people were made, as also of the expenditure in the form of human energy and factors for other sources of energy. Human energy data are examined in terms of seasonality whereas energy expenditure from all other sources are aggregated for the whole year. Data were collected from Nov. 1980 to Oct. 1981. It was found that the domestic activities required 23.79 × 10^6 kcal in the form of human energy, agricultural activity needed 8.53 × 10^6 kcal, and the employment, and trade activities required 18 × 10^6 kcal in the form of human energy

The total energy expenditure from all sources (human, animal, firewood, straw, grass, dung and food) was found to be 1122.43 × 10^6 kcal/year or 11390 kcal/capita/day.

It was observed that the human life is highly dependent on the ecosystem which alone provides food and employment.

INTRODUCTION

1. The Purpose

During the last decade quite a number of studies have been carried out which examine the energy utilisation/consumption patterns in villages. The main objectives of this study are:

(a) to identify areas of rural life demanding different energy sources, different end-use forms of energy and energy converters
(b) to identify activities consuming significant amounts of energy from different sources

---

* *(Paper presented at the seminar on 'Application of System Analysis for Development of Rural Areas' held at Bombay on 10 April 1988*

(c) to highlight the contribution of non-commercial forms of energy in the sustenance of rural life.
(d) to understand both the economic and the ecological implications of the present forms of energy utilisation and therefore reflect the policy alternatives which would assist in the alteration of the present pattern.
(e) to assist in prioritisation of needs, to aid assessement of local resources and hence to assist in an objective definition of appropriate technologies.
(f) to assist in the development of technological perspectives relating to conscious transition of rural life from the present levels of depravity to improved levels of quality of life.

Studies carried out by Revelle (1976), Ravindranath, *et al.* (1980), Maheshwari, *et al.* (1981), Jodha, *et al.* (1971), Gupta (1979) and Kulkarni, *et al.* (1979), are some of the contributions towards realising the above-mentioned objectives.

This paper presents the energy consumption/utilisation pattern determined for a hamlet, Shilarwadi, which is situated 120 km north-east Bombay in the Karjat Tribal Block of Taluka Karjat, Dist. Raigad, Maharashtra State. The raw data necessary for development of the energy utilisation pattern were collected essentially during November 1980 – October 1981, with subsequent checks in later years in respect of some of the data. Detailed notes of activities and assets of the tribals of Shilarwadi were made by staying amongst their midst.

1.1 The setting

The Karjat Tribal Block is situated at the foothills of Sahyadri range of mountains. The block is inhabited by tribals (53%) and Marathas (47%). The total area of the block is 396.6 sq. km (32,380 ha), comprising flat paddy lands, sloping (varkas) lands and forest lands. The block consists of 46 villages and 96 associated hamlets. The 36,150 population of the block lives in these villages and hamlets; the tribals live almost exclusively in the hamlets and Marathas predominate the villages.

The hamlet of Shilarwadi is a typical habitat of Thakur tribals. It is located on a hillock unconnected by roads or electricity. The major sources of livelihood for the people are a single crop, rain-fed agriculture (mainly paddy and Nachni/Vari) collection and selling of forest produce such as fruits, gums, flowers and fibres and also working as agriculture labour in a neighbouring irrigated area or felling trees in forests on behalf of contractors. Occassionally, work is also found in road construction, electrical cable laying,etc. Most families own cattle, goats and poultry; they also own either forest land or cultivable land.

In spite of the 3000 mm rainfall, the block suffers from shortage of water between March and June because of high run-off and low recharge. The Shilar river below the Shilarwadi flows between June and February. Down the slope of the river are three wells which dry up by April and for about a month and a half the people often have to fetch water from the pools formed in the river.

A majority of the families in Shilarwadi suffers from indebtedness and lack of secure employment. As it is an isolated hamlet, none of the public services such as health, education, electricity, post, banking, etc. have reached Shilarwadi. The people thus live on the basis of their knowledge of nature which surrounds them. The means available to exploit this knowledge are however limited by indebtedness, by the regulations of the forest department, by buying up of lands by urbanites from Bombay, etc., which have reduced their control over the forest and pasture lands. Lack of education, of purchasing power and of entrepreneurship skills are added bottlenecks which find them no place in the market system or make them honourable recipients of the benefits intended in government schemes.

Overall, the situation is one of no social and political control over the market and the bureaucracy, and steadily the control over the natural environment is receding.

2. Basic Data on Shilarwadi

2.1 Assets of the poeople

The data on population, land distribution, livestock, trees and water resources are provided in *Table 1 (a-e)* respectively. It is seen that the average family size is 5.86 with nearly 70% of the 46 families having a size of 4 to 7. The adult males and females number equally and account for nearly 59% of the total population of 270.

The total land holding is 161.5 ha, 49.4% of which is cultivable and is owned by 30 families (out of 46 families). According to the census data, the cultivable land in the tribal block is 66% of the total with a total land availability of 0.8957 ha/person. The total land availability in Shilarwadi is only 0.598 ha/person.

The cattle heads per family in Shilarwadi are 4.63, which is higher than the national average of 1.7

The village common (3.2 ha) consists of 45 fruit trees and 101 other large trees. In addition, the common consists of shrubs some of which produce oil-bearing fruits, some can be used for making rope fibre and others for medicinal purposes.

TABLE 1 a
POPULATION DATA

Age- and sex-wise break-up

Sex Range	0 – 5	5 – 15	15 – 30	30 – 40	40 – 50	50 – 60
Males (76)	–	–	45	12	7	12
Females (77)	–	–	29	23	13	12
Boys (60)	32	28	–	–	–	–
Girls (57)	30	27	–	–	–	–
Total (270)	62	55	74	35	20	24
Per cent (100)	23%	20.4%	27.4%	13%	7.4%	8.8%

Family-wise break-up

Family Size	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of Families (46)	1	6	6	14	5	7	2	1	0	1	0	1	2
Total (270)	2	18	24	70	30	49	16	9	0	11	0	13	28

Average family size, 5.86

TABLE 1b
LAND DISTRIBUTION

Land Classification

Type of land	*ha*	*acre*	*ha/person*	*acres/person*
Paddy	26.0	65.0	0.0963	0.240
Slopping	53.40	133.50	0.1978	0.494
Total cultivable	79.40	198.50	0.294	0.735
Forest	82.10	202.25	0.304	0.76
Total land	161.50	403.75	0.598	1.495

Land Distribution

	No. of families	
Land holding (ha)	*Cultivable*	*Forest*
No. Land	16	18
0-1	5	19
1 -2	6	3
2-5	7	1
5-9	12	5
Total	46	46

Village Common: 3 acres

TABLE 1c
ANIMAL HEAD DATA

Name	*Number*	*Per cent*	*Per family*
Goats	47	18.01	1.00
Cows	81	31.03	1.76
Bullocks	28	10.73	0.609
Calves	27	10.35	0.587
She-Buffallos	9	3.45	0.196
He-Buffallos	21	8.05	0.457
Total Cattle Head	213	81.61	4.63
Poultry	48	18.4	1.00
Total	261	100	5.674

TABLE 1d
TREES IN VILAGE COMMON

Fruit Trees	*No.*	*Large Trees*	*No*
Guava	3	Banyan	3
Jackfruit	7	Limbara	8
Banana	3	Bamboo	2
Jamboon	2	Tamarind	5
Cashewnut	3	Teak	5
Popai	21	Bhendi	4
Ramphal	2	Mango	14
Sitaphal	4	Wild Champa	14
Total	45	Shevga	44
		Shivan	2
		Total	101

TABLE 1 e
WATER RESOURCE DATA

Diameter	5.10 m (17 ft)	3 m (10 ft)	33 m (11 ft)
Depth	4.5 m (15 ft)	4.8 m (16 ft)	6.3 m (21 ft)
Height above river	27 m (90 ft)	19.5 m (65 ft)	3 m (10 ft)
Month of drying up	January	March	April

The three wells are essentially water tanks as they do not recharge after the monsoon. The scarcity of water beyond March can be readily appreciated from *Table 1e*.

In addition, the agro wastes and other tools and equipment provide further assets. The agro wastes are essentially of 4 types: (a) paddy straw, (b) nachni straw, (c) grasses and (d) ambadi fibre.

The average yield of paddy straw is 515 bundles per acre or 775 kg/acre. Rice husk from rice mills is not recovered. The rice straw is used for thatching roofs (600 bundles for a 13 ft × 13 ft house) and as animal feed. The nachni straw yield is about 1000 kg/acre. It is not cut and bundled but left standing in the field. The straw dries up very quickly and disintegrates by the end of November into grass. When green, it is consumed by animals. Ambadi is a vegetable group interspersed with nachni that provides fibre. About 2 kg of fibre/acre is obtained. The fibre is twisted into rope. The yields of natural grass are not known.

The people of Shilarwadi possess seven types of agricultural tools, five types of carpentry tools and five hunting and fishing tools.

2.2 Activities

For a people who live so close to nature, almost all activities are governed by seasonality. Secondly, much of the production is for self-consumption. Hence, it is possible to list the activities under the following four heads.

Domestic

Firewood collection, cooking, space heating, lighting, fetching water, fishing, hunting and kitchen gardening.

Agricultural

Rab preparation, nursery raising, puddling, transplanting, weeding, harvesting, threshing and storage.

Livestock

Animal grazing and caring.

Employment & trade

Forest collection, agricultural labour, forest cutting, bamboo work, etc.

All activities require expenditure of time and energy and some of them involve exchange of money. The main sources of energy are: (a) human energy, (b) animal energy, (c) cattle dung, (d) firewood and grasses, and (e) kerosene.

There is no electricity in Shilarwadi, nor is there any petroleum-based fuel used for mechanical power. People of Shilarwadi do not use any chemical fertilisers. In the money system, all activities are valued through prices. Prices, however, are governed by the laws of the market and often do not reflect true costs or benefits to society and the environment. Energy and time values of an activity on the other hand are governed by the laws of nature. Prices thus often over- or under-value activities resulting in non-equivalence between time, energy and money.

In this paper all activities are evaluated in terms of time and energy. The flows of energy between human, animal, agricultural and forest subsystems of the total system of Shilarwadi are worked out. To do this, it is necessary to know the energy equivalents of all human tasks as well as the energy content of non-human sources of energy. These are considered in the next section.

3. The Energy Factors

3.1. Human energy *(Table 2)*

The most generally used values for human energy expenditures in rural areas are: 250 kcal/h for men, 200 kcal/h for women, and 120 kcal/h for children. [Revelle (1976), Ravindranath, *et al.* (1980)]. While these figures are often quite adequate for the average yearly data, in a strongly seasonally determined lifestyle, they do not present a correct quantification on a weekly or monthly basis. This is because different activities are carried out with different intensities, and under different climatic conditions. Thus all human activities (A) are first characterised by:

Activity (A) = F (labour time, postures, distance travelled, climatic conditions)

Books on ergonomics give energy costs of typical activities involving muscular work. These activities do not, however, correspond exactly to those that are carried out in Shilarwadi. Hence, approximations are made about which detailed discussion can be found in observations.

4. Human Energy Expenditures

4.1 Selection of families

As mentioned in Section 2, Shilarwadi has 46 families. Since it was different to monitor the activities of people in all households, the number of families monitored was limited to six. A graph of family size

TABLE 2
HUMAN ENERGY COSTS

Activity	*Man*	*kcal/min Woman*	*Child*
DOMESTIC			
a) Cooking	–	1.9	–
b) Firewood collection	5.68	4.54	2.84
c) Fetching water	–	5.0	3.0
d) Fishing & hunting	2.0	–	–
e) Kitchen gardening	3.0	–	–
AGRICULTURE			
a) Gobar collection	4.0	–	–
b) Branch cutting	5.68	–	–
c) Grass collection	2.5	–	–
d) Soil digging	8.4	4	–
e) Nursery raising	6.0	3.0	–
f) Fencing	–	3.0	–
g) Puddling	6.5	–	–
h) Trasplanting	–	4.5	–
i) Weeding	3	2.4	–
j) Harvesting	6.0	4.8	–
k) Threshing & storage	7.0	3	–
LIVESTOCK			
a) Grazing	–	–	1.29
EMPLOYMENT & TRADE			
a) Forest cutting	9.8	–	–
b) Agricultural labour	4.3	3.4	–
c) Bamboo work	3.0	–	–
d) Forest produce collection	4.5	3.6	2.25
e) Trading	3.5	–	–

Energy factors for other sources

Source	*Energy Content*
Firewood	4000 kcal/kg
Kerosene	8500 kcal/litre
Animals	2100 kcal/hr
Agrowaste	3800 kcal/kg
Dung (manure)	158 kcal/kg dry
Dung (fuel)	2444 kcal/kg dry
Rice, Nachni, Vari	4000 kcal/kg
Pulses	4200 kcal/kg
Jaggery	7500 kcal/kg
Vegetables	4000 kcal/kg
Milk	670 kcal/litres
Meat, fish	1700 kcal/kg
Oil	2000 kcal/kg

versus land holding was plotted. The data points were then split into four quadrants, and one family was chosen from each quadrant. In addition, two large families (14 members each) with large (9 ha) and small (0.44 ha) land holdings were selected. The total population of the six families is 49 or 18.15% of the total population and the total land holding is 25.9 ha or 15% of the total land. *Table 3a* shows the characteristics of the chosen families. Since the data were collected through participant observation, the veracity of the data was checked through spot observations in relation to the other families in respect of certain activities.

TABLE 3a
CHOSEN FAMILIES

	Family Details	F_1	F_2	F_3	F_4	F_5	F_6
1.	Size	14	14	5	5	8	3
2.	Paddy land (ha)	2.5	0.04	2.0	2.5	2.0	1.0
3.	Varkas land (ha)	1.0	0.20	0.60	2.0	2.7	Nil.
4.	Forest land (ha)	5.5	0.20	0.80	0.9	2.0	Nil.
5.	Males	5	6	1	3	2	1
6.	Females	4	5	1	1	2	1
7.	Children	5	3	3	1	4	1
8.	Cows	5	6	3	7	6	1
9.	Bullocks	4	Nil	Nil	2	Nil	1
10.	He-Buffalos	5	2	Nil	Nil	3	2
11.	She-Buffalos	1	1	Nil	Nil	Nil	Nil
12.	Goats	5	4	Nil	Nil	Nil	1
13.	Poultry	9	Nil	Nil	10	13	9

4.2 Domestic activities

The human hours spent in domestic activities are shown in *Figure 1a* . It is seen that each activity shows seasonality. For example, cooking hours are less from May to September simply because fewer meals are cooked, compared to the other months when the food availability is better. Similarly, March, April and May consume considerable time in fetching water as women have to walk long distances for this purpose. Firewood collection activity is concentrated in non-monsoon months when the firewood is dry and easy to cut.

Similarly fishing and hunting activities are concentrated between October and March when there is relatively free time available. Subsequently from April to June, collection of forest produce takes up considerable time.

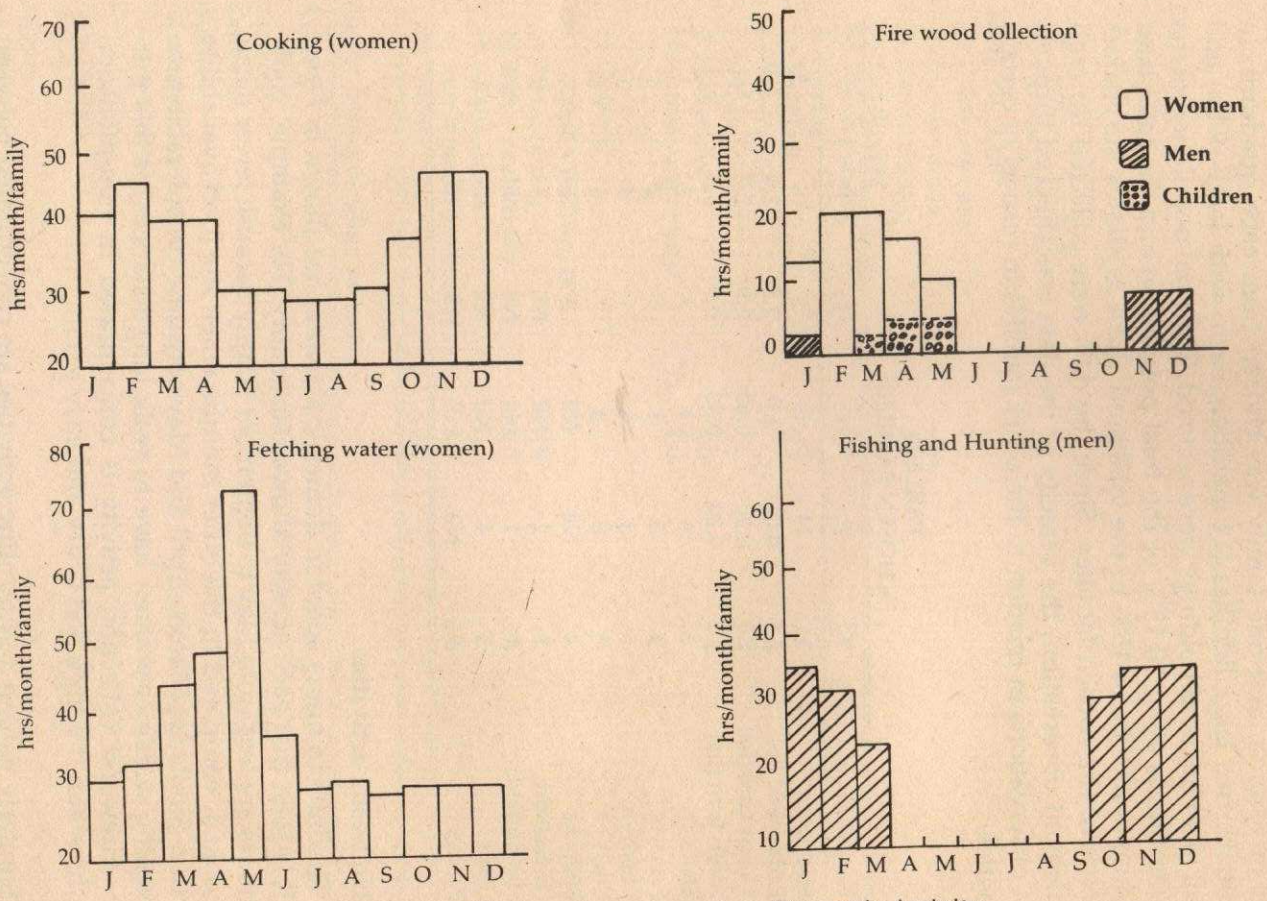


Fig. 1a. Human energy spent on Domestic Activity

4.3 Livestock raising

The human hours spent in livestock raising are shown in *Figure 1b*. It is seen that children spend the maximum hours on this activity. Women hours are spent essentially on care of cattle. Men engage in feeding and milking activities.

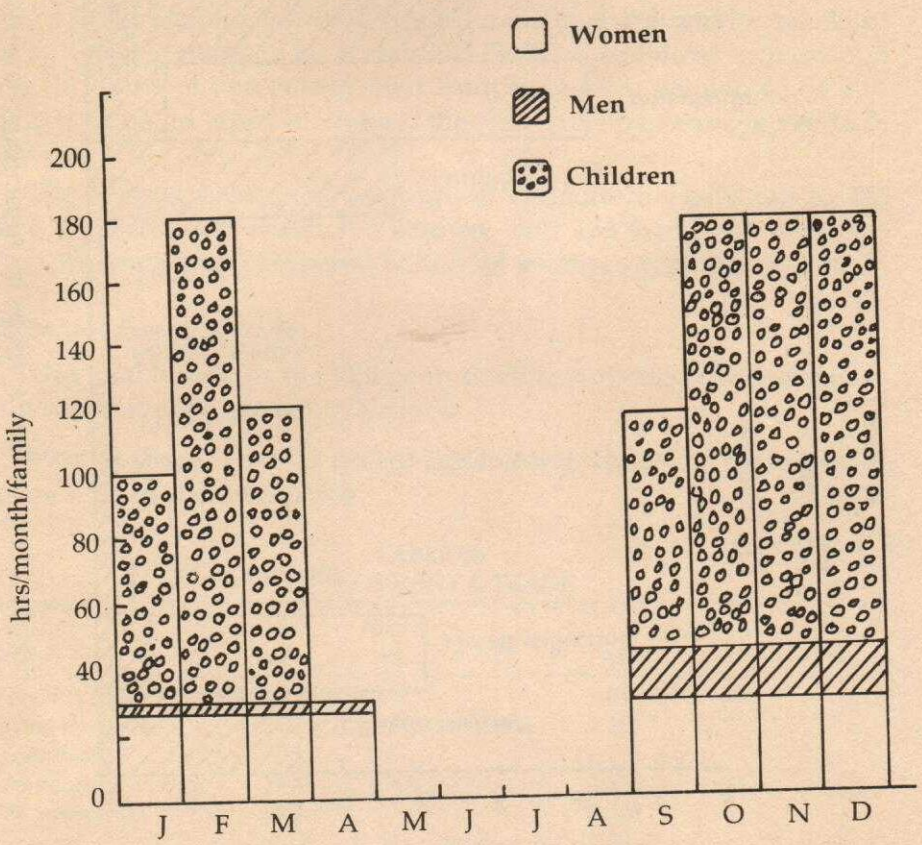


Fig. 1b Human hours spent in Live Stock Raising

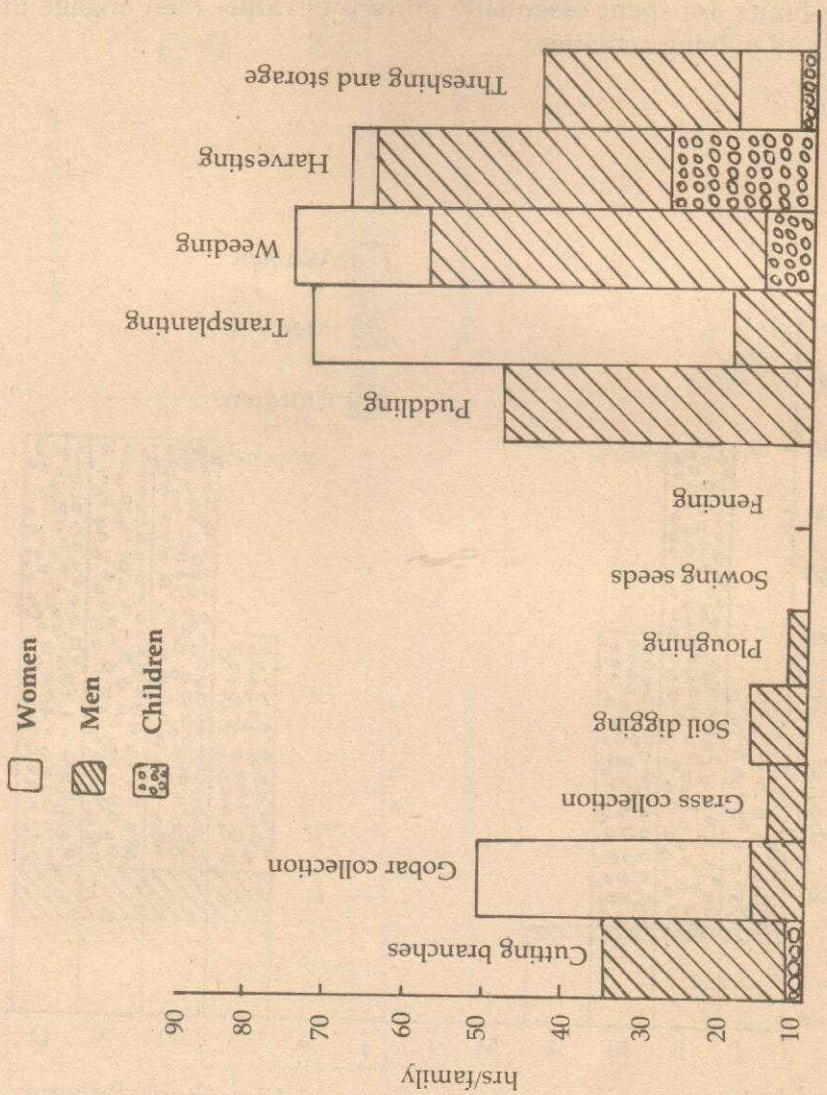


Fig. 1c. Human hours spent in Agriculture (Activity wise)

4.4 Agriculture

The activity-wise and monthly hours spent in agriculture are shown in *Figures 1c and 1d* respectively. Transplanting and weeding require a large number of hours. Similarly rab preparation (i.e. first four activities) take up considerable time. Harvesting is also time-consuming. The months of July and August show a peak labour demand in agriculture. The activity-wise chart follows more or less the monthly chart except that the month of May is entirely spent on the non-agricultural activity of collection of forest produce. In terms of energy expended, the post-harvest operations require 37.4% of total human energy in agriculture whereas the premonsoon rab activity takes up 23.6% human energy. The remainder (39%) is provided in monsoon itself. In terms of percentage, men contribute 45.3, women 43.04 and children 11.64. In terms of energy, the respective percentages are 56.9, 36.93 and 6.17.

The average energy expenditure in agriculture works out to 325 kcal/h for men, 220 kcal/h for women, and 136 kcal/h for children. These are quite high compared to annual averages typically assumed.

4.5 Employment & trade

The total hours for the village in the five activities under employment and trade are shown in *Table 3b*.

Most of these activities except agricultural labour are performed in the months of April and May.

TABLE 3b
EMPLOYMENT & TRADE

	Hours			*kcal* $\times 10^6$		
Activity	*M*	*W*	*C*	*M*	*W*	*C*
1 Forest cutting	12000	–	–	7.056	–	–
2. Forest produce collection	12481	13340	13202	3.35	2.88	1.78
3. Agriculture labour	2700	2700	–	0.675	0.54	–
4. Bamboo work	1800	–	–	0.324	–	–
5. Trading	6624	–	–	1.39	–	–
Total	35605	16040	13202	12.8	3.42	1.78

4.6 Summary

The total human hours and their energy equivalents in domestic (including animal raising), agriculture, trade and employment for the entire village are shown in *Table 3c*.

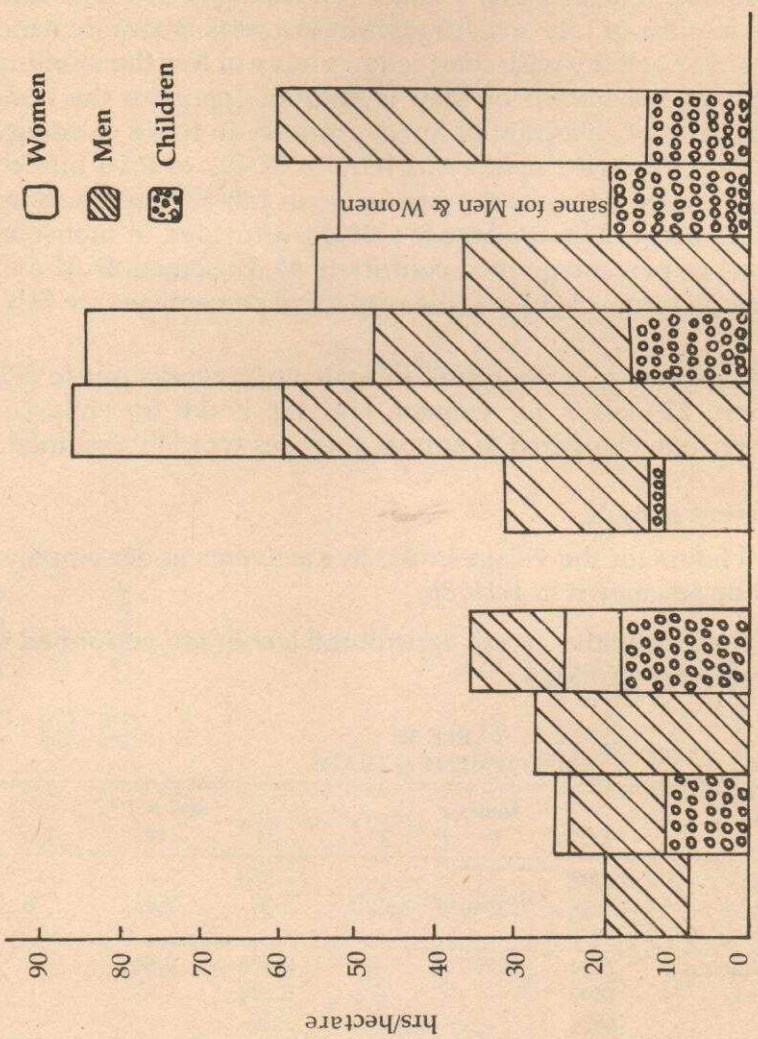


Fig. 1d. Monthly human hours spent in Agriculture

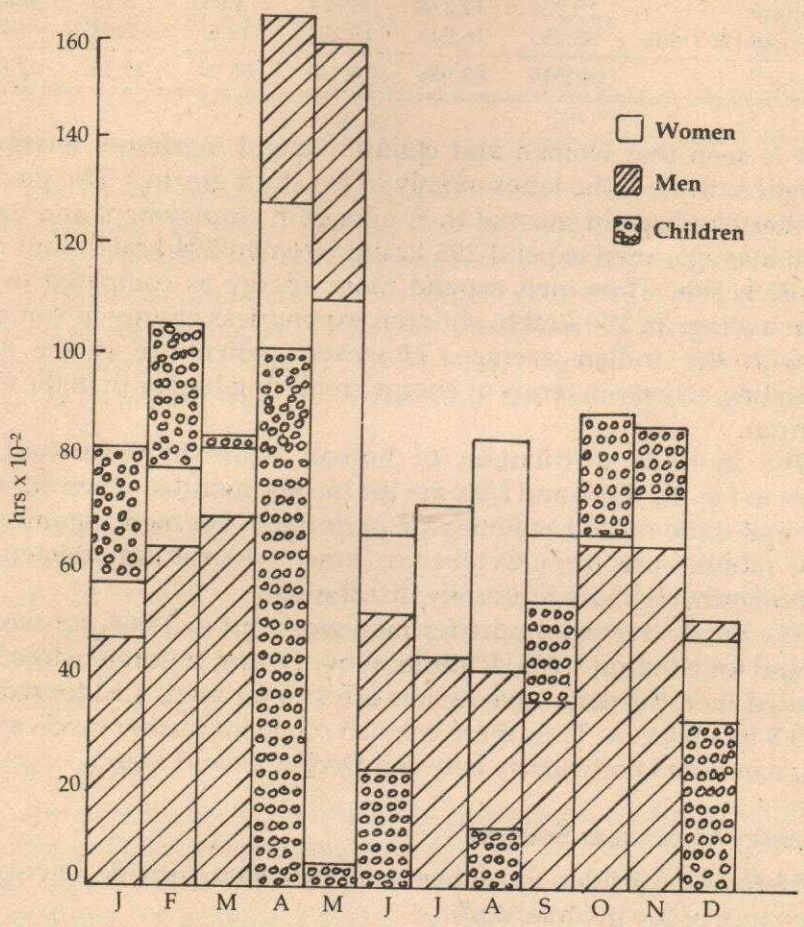


Fig. 1e. Total monthly distribution of human hours in Shilarwadi

TABLE 3c
SUMMARY OF ALL ACTIVITIES (Sector-wise)

	Hours			*kcal* $\times 10^6$		
Activity	*M*	*W*	*C*	*M*	*W*	*C*
Domestic	31,934	63,612	59,074	6.53	12.58	4.68
Agriculture	15,026	14,274	38,664	4.85	3.15	0.523
Employment & Trade	35,555	16,040	13,202	12.8	3.42	1.78
Total	82,515	93,926	76,140	24.18	19.15	7.0

It is seen that women and children spend maximum energy in domestic activities, the latter mainly in livestock grazing. The men on the other hand spend most of their energy in employment and trade. On an average, men expend 293 kcal/h, women 204 kcal/h, and children 92 kcal/h. Thus men expend more energy as compared to the Indian average of 250 kcal/h; children expend less energy in comparison with the Indian average. However, agriculture is the most demanding activity in terms of energy, requiring higher than the average input.

The monthly distribution of human hours in Shilarwadi are shown in *Fig. 1e*. April and May are the busiest months, when employment and trade-related activities are performed. For men, significantly active months are from October to June, whereas for women the human hours are more uniformly distributed.

The yearly average hours for men work out to 2.964, for women 3.31 and for children 1.786. If adults above 50 and children below 5 are excluded then the respective figures are 4.16 for men, 4.62 for women and 3.8 for children. Thus there is much scope for further involvement of human hours particularly between December and March.

5. Energy from other Sources

Here we consider the other sources which provide energy for sustenance of life in Shilarwadi.

Source	*Use*
Firewood	Cooking, space-heating, rab
Kerosene	Lighting
Animals	Ploughing & puddling
Dung	Rab and manure
Grasses	Rab, fodder
Rice straw	Fodder
Food	Human consumption

The firewood consumption for Shilarwadi is shown in *Table 4a*.

TABLE 4a
FIREWOOD CONSUMPTION

Activity	*kg*	*kcal* × 10^6	*Remarks*
Cooking	39,095	156.38	850 kg/family
Space heating	35,593	142.37	4.5 kg/sq. ft floor space
Rab	42,750	171.00	450 kg/acre
Total	1,17,238	469.75	

The fuel wood data show that its consumption in cooking is 850 kg/family/year. In space heating and rab, the respective figures are 773.75 kg and 929.35 kg. Thus agriculture is the largest consuming sector of firewood, unlike the usual national estimates which show cooking and space heating as the largest consumers. Incidentally the space heating consumption turns out to be 4.5 kg/sq.ft of floor per year. Since 38 ha are cultivated in Shilarwadi, the firewood in rab is 450 kg/acre.

Kerosene

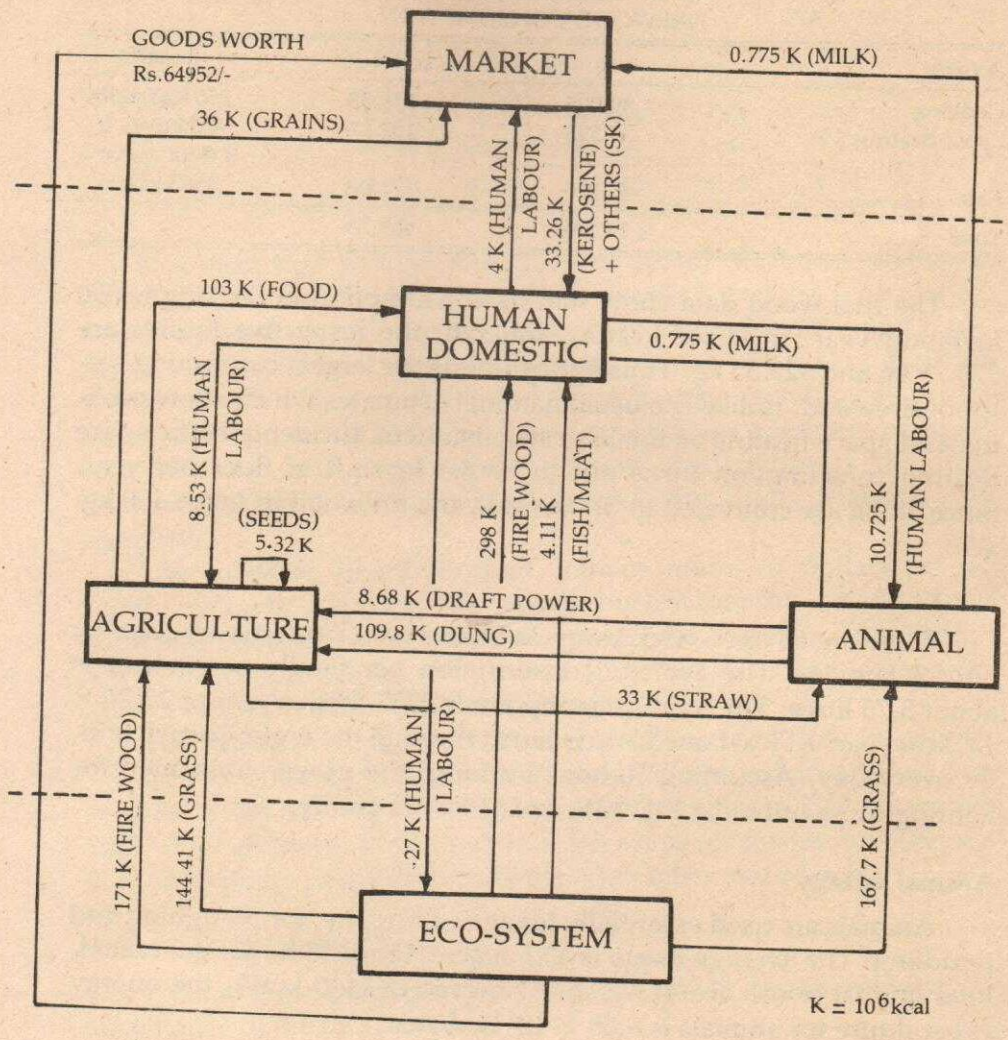
There are 60 open-wick lamps in Shilarwadi. Lanterns are used by only 3 families. The average consumption per family per month is about 3.75 litres. The total consumption is 2737.5 litres/year or 23.26 × 10^6 kcal/year. At least one lamp is burnt through the night by each family every day. Assuming 10-hour burning, the power consumed for lighting turns out to be 7.41 kW, or 161 W per family.

Animal energy

Animals are used essentially for agriculture, i.e. for ploughing and puddling. The average usage is 43.5 h/acre. Since 38 ha are cultivated, total animal hours are 4132.5 h. At the rate of 2100 kcal/h, the energy expenditure for animals is 8.68 × 10^6 kcal/year.

Rice straw and grasses

The total availability or rice straw is 775 × 26 × 2.5 = 50,375 kg since 26 ha of paddy land is cultivated. Out of this, 40,420 kg are used for thatching. The remainder is used as animal feed. Animals are fed with grass both at home and through grazing. The grass consumption is estimated at 56.9 tons out of which 13 tons were estimated to be consumed at home. The total animal feed of grass and straw is thus 66.9 tons. At the rate of 3000 kcal/kg, this works out to 200 × 10^6 kcal/year.



'OTHERS' INCLUDE ITEMS OF FOOD CONSUMPTION (SK) AND CLOTHING
'ECOSYSTEM' IMPLIES FOREST AND PASTURE LAND

FIG.2 Energy Flows in Shilarwadi

In addition, grass is also used in rab cultivation at the rate of 400 kg/acre or 144 × 10^6 kcal per year. *Table 4b* summarises the uses of rice straw and grass.

TABLE 4b
USE OF RICE STRAW & GRASS

Material	*Use*	*Qty, tons*
Straw	Thatching	40.42
Straw	Animal feed	10.00
Grass	Animal feed	56.9
Grass	Rab	38.0

Cattle dung

Cattle dung is used in rab (450 kg/acre) and in manuring. The respective estimates are 42.75 tons and 34 tons. Since in rab the dung is burnt, the energy output is 42.75 × 10^3 × 2444 = 104.5 × 10^6 kcal/year while as manure the energy output is 5.3 × 10^6 kcal/year. The total energy from dung is 109.8 × 10^6 kcal/year or 1.147 × 10^6 kcal/acre.

Food energy

The food consumption data were the most difficult to ascertain as people were reluctant to disclose the actual quantities of grain paid in debt repayment and of fresh grain borrowed. Some families purchased their food grains. However, data were inferred from landholding, money earned through employment, actual monitoring of food cooked at intervals of week and from the amount of firewood consumed in cooking. The variations, particularly in rice consumption, were found to be of the order of 20 per cent. Hence these data must be treated as tentative.

The food consumption data is given in *Table 4c* in terms of kg/adult/male/year; where adult male was estimated as:

$$\begin{aligned}\text{Adult male} = {} & 1 \times \text{no. of adult males} \\ & + 0.8 \times \text{no. of adult women} \\ & + 0.5 \times \text{no. of children}\end{aligned}$$

The total number of adult males in Shilarwadi works out to 196.5. The food energy intake is 0.6026 × 10^6 kcal/year/adult male, or 1651 kcal/day/person. This is very low as compared to the recommended figure of 2400 to 2800 kcal/day/person. The figure of 1651 explains the low life expectancy in tribal regions. Also, if 600 kcal/day is consumed

by the basal metabolism then the energy available for doing work is only 1051 kcal/day. No wonder then that men carry out typically 4 h of work per day on the average, as was noted in Section 4. *Table 4c* does not account for energy obtained from consumption of liquor (made from 1890 kg of mahua flowers collected) and sour roots (300 kg collected from forest).

TABLE 4c
FOOD CONSUMPTION

Item	*kg/adult male/year*	*kcal* $\times 10^6$*/year*
Rice	89	0.355
Nachni	18.23	0.073
Vari	4.83	0.0193
Pulses	6.40	0.0269
Jaggery	0.84	0.0063
Oil	0.735	0.00147
Vegetables	20.3	0.0811
Fish	8.7	0.0148
Meat	3.96	0.0067
Milk	5.97	0.004
Wheat	2.00	0.008
Total	160.965	0.6026

6. Energy Efficiencies and Flows

We now consider energy efficiencies of the four sub-systems of Shilarwadi, i.e. human beings, animals, agriculture and, the forest ecosystem. The inputs and outputs for each system have been worked out from the data presented so far. We assume that these systems exchange only energy between them. Note that some of the items of food are purchased from the market and forest produce is sold to the market. As such, interactions with market (i.e. money exchanges) are also considered.

6.1 Human system

The energetic efficiency is thus: 50.315/116.3 = 0.4326. This indicates that almost all the energy for doing work available to humans (besides the basal energy) is being utilized in Shilarwadi. *(Table 5a).*

TABLE 5a
INPUT-OUTPUT FOR HUMAN SYSTEM

Input from	*kcal* × 10^6	*Output to*	*kcal* × 10^6
Agriculture	103	Agriculture	10.73
Animals (milk)	0.775	Animal raising	8.53
Market	8.3	Market	18.00
Forest	4.19	Domestic	10.06
Ecosystem		Ecosystem	
Total	116.3		50.315

6.2 Agricultural system

Shilarwadi cultivated 26 ha of paddy land and 12 ha of Nachni land during the year under consideration with yields of 350 kg/acre and 400 kg/acre respectively. In addition, this system provides 775 kg/acre of rice straw, 1000 kg/acre of Nachni straw, and 2 kg/acre of Nachni land of ambadi fibre.

TABLE 5b
INPUT-OUTPUT FOR AGRICULTURE

Input from	*kcal* × 10^6	*Output to*	*kcal* × 10^6
Human	8.53	Human (grain)	139.00
Animal	8.68	Animal (feed)	33.00
Agriculture (seeds)	5.32	Agriculture	121.26
Ecosystem (+ dung)	419.50	Domestic (thatching)	5.32
Total	442.03		298.58

The overall efficiency is 298.58/442.03 = 0.675. If it is assumed that the contribution from ecosystem does not represent any forage consumption, then grain energy gain ratio in agriculture is 139/22.53 = 6.17. This is the main reason why subsistence agriculture is still attractive in spite of low yields.

6.3 Animal system

Energy accounting for the animal system is provided in *Table 5c*. The output/input ratio is 120/218.425 = 0.549

Note that human beings consume 1157 litres of milk (or 0.0689 litres/day/family) and sell 1113 litres to the market.

TABLE 5c
INPUT-OUTPUT FOR ANIMAL SYSTEM

Input from	*kcal* × 10^6	*Output to*	*kcal* × 10^6
Human	10.725	Human (milk)	0.775
Agriculture (straw)	40.00	Agri (draft power)	8.680
Forest ecosystem (straw)	167.70	Agri (dung+manure)	09.80
		Market (milk)	0.746
Total	218.425		120.00

6.4 Forest ecosystem

It is difficult to work out energy equivalents of all the items obtained from the forest. In any case, some items are directly sold for cash. As such, the inputs and outputs are worked out in terms of appropriate units.

The forest system contributes to earnings from the market, and sustains human and animal life directly and through agriculture. The relevant figures are:

Market

Karvande (25825 kg), Mahua seeds (4185 kg), Gum (55 kg), Jamboon (3400 kg), Palas leaves (675 kg), Dhaity flowers (1070 kg), Raw mango (400 kg), Fish (685 kg), forest cutting employment (2000 man days). The net earnings from all these is Rs.64,952/- or Rs.1412 per family per year.

Human

Firewood (74.5 tons), Mahua flower for liquor (1890 kg), Sour roots (300 kg), Tamboorni leaves for beedies (650 kg), and Fish (1600 kg).

Agriculture

Firewood (42.75 tons) and Grass (30 tons).

Animals

Grass (55 tons)

The total human energy input is estimated at 27.825 × 10^6 kcal/ year, which is obviously much lower than the total output of the forest ecosystem. Thus the life in Shilarwadi is largely supported by the forest ecosystem.

6.5 Energy flow in the total system

The energy flow in the total system of Shilarwadi comprising essentially human + domestic, agriculture and animal sub-systems is shown in *Figure 2*. This system interacts with the forest ecosystem and with the market. The forest ecosystem essentially comprises the total land (161.50 ha) minus the cultivated land (38 ha), i.e. 123.5 ha.

The figure confirms the view that life in Shilarwadi is essentially supported by the forest ecosystem rather than the market. For an input of 27×10^6 kcal of human energy, the ecosystem provides 785×10^6 kcal, mainly in terms of firewood and grass, as well as earnings of Rs.64,952/-.

Interactions with market cannot be assessed easily as the energy content of 37,210 kg of forest produce is not exactly known. However, assigning an average figure of 1000 kcal/kg, the energy supply to market is 37.21×10^6 kcal. In addition, the market receives 36×10^6 kcal in terms of grain and 4×10^6 kcal in terms of agricultural labour and 0.7×10^6 kcal in terms of milk i.e. a total of 78×10^6 kcal. In return, the market provides input of only 23.26×10^6 kcal in terms of kerosene and 8×10^6 kcal in terms of food and clothing, i.e. a total of 31.26×10^6 kcal. Thus, the interaction with market represents an energy loss of 46.75×10^6 kcal annually, the actual energy content of wood transported to the market not being counted.

7. Comparison of Shilarwadi with Ungra and Islamnagar

It is now in order to compare the results of Shilarwadi with those available for two other villages: Ungra in Karnataka and Islamnagar in Madhya Pradesh. Brief data on Ungra and Islamnagar are given in *Table 6a*.

TABLE 6a
DATA ON UNGRA AND ISLAMNAGAR

	Ungra	*Islamnagar*
Population	932	1529
Cattle + sheep	949	1436
Total land (ha)	360.2	719
Major crop	Paddy (Kharif)	Wheat (Rabi), Paddy (Kharif)
Area sown (ha)		
Kharif	201	86.21
Rabi	29.5	317.7

TABLE 6b

ENERGY SOURCE – ACTIVITY MATRIX (kcal × 10^6)

Source	*Human*	*Agriculture*	*Domestic*	*Employment & Trade*	*Animal raising*	*Total*	*Per cent*
1. Human	–	4.852	2.678	12.8	3.85	24.18	2.11
Men							
Women	–	3.15	10.196	3.42	2.385	19.15	1.67
Children	–	0.528	0.19	1.78	4.99	7.00	0.61
2. Animal	–	8.68	–	–	–	8.68	0.76
3. Firewood	–	171.0	298.0	–	–	469.0	41.0
4. Straw	–	–	–	–	33.0	33.0	2.89
5. Grass	–	144.4	–	–	167.7	312.1	27.3
6. Dung	–	109.8	–	–	–	109.8	9.61
7. Food	116.3	–	–	–	–	116.3	10.18
8. Kerosene	–	–	23.26	–	–	23.26	2.04
Total	116.3	442.41	334.32	18.0	211.4	1122.43	100
Per cent	10.18	38.72	29.26	1.57	18.5	100	

Energy/capita/day = 11.39 × 10^3 kcal

TABLE 6c
ENERGY SOURCE – ACTIVITY MATRIX (kcal × 10^6)
Ungra, Karnatak State

Source	*Human*	*Agriculture*	*Domestic Employment*	*+ Trade & Industry*	*Animal raising**	*Total*	*Per cent*
Human	–	51	120	31.7	NA	202.7	3.0
Animal	–	84.3	–	7.8	–	92.0	1.37
Firewood	–	–	1564.2	258.7	–	1823	27.13
Rice Straw	–	–	162.7	–	1839	2002	29.8
Grass	–	–	–	–	1225	1225	18.23
Dung	–	NA	–	–	–	–	–
Food*	1276	–	–	–	–	1276	[illegible].0
Electricity	–	22.3	8.2	2.6	–	33.1	0.49
Kerosene	–	–	49.6	6.8	–	56.4	0.84
Diesel	–	0.3	–	–	–	0.3	0
Coal	–	–	–	9.9	–	9.9	0.147
Total	1276	158	1904.7	317.5	3063	6719	
Per cent	19	2.35	28.33	4.7	45.58	100	

Energy/capita/day = 19.75 × 10^3 kcal

* Our estimates based on human hours in animal raising are not specified

TABLE 6d
ENERGY SOURCE – ACTIVITY MATRIX (kcal × 10^6)
ISLAMNAGAR, MADHYA PRADESH

Source	*Human*	*Agriculture*	*Domestic*	*Employment + Trade & Industry*	*Animal raising*	*Total*	*Per cent*
Human	–	7.48	27.88	Nil	18.1	53.46	0.44
Animal	–	241.8	–	–	113.5*	355.3	2.93
Firewood	–	–	1899	–	–	1899	15.7
Grass	–	–	–	–	3821**	3821	31.6
Straw	–	–	–	–	1987**	1987	16.4
Dung	–	–	1194.4	–	–	1194.4	9.87
Food**	2137	–	–	–	–	2137	17.66
Kerosene	–	–	61.54	–	–	61.54	0.51
Diesel	–	116.7	0.237	–	2.72	119.65	0.99
Electricity	–	45.88	27.95	–	–	78.83	0.65
Fertilizer + embodia energy	–	395.5	–	–	–	395.5	3.27
Total	2137	807.4	3211	–	5933	12997	
Per cent	17.66	6.67	26.54	–	49	100	

Energy/capita/day = 21.67 × 10^3 kcal

* Animal energy used in raising fodder crops.
** Estimates as per 3.

The comparison of Shilarwadi is made with these two villages by means of a energy source-activity matrix (see *Tables 6b, c, d*). It is clear that Islamnagar enjoys higher per capita energy consumption (21.6×10^6 kcal) than Shilarwadi (11.39×10^6) and Ungra (19.75×10^6 kcal).

Energy spent in animal raising is nearly 47% of the total in Ungra and Islamnagar whereas it is only 18.5% in Shilarwadi. On the other hand, agriculture in Islamnagar consumes 6.67%, in Ungra 2.35% and in Shilarwadi 38.72%. The main contributor to this large percentage in Shilarwadi is the energy input in rab cultivation practice. Note that Islamnagar uses chemical fertilisers whereas input through dung manure is not known for Ungra. The food energy in Shilarwadi is only 10.18% of the total whereas it is 17.66% in Islamnagar and 19% in Ungra. The domestic activity consumes about 27% in all villages. Contribution of employment trade and industry is 1.57% in Shilarwadi and 4.7% in Ungra. There is no industry in Islamnagar.

In terms of energy sources, firewood provides 41% in Shilarwadi, 15.6% in Islamnagar and 27.13% in Ungra. Straw, cowdung and grass provide 39.8% in Shilarwadi, 57.87% in Islamnagar and 48.03% in Ungra. The large contribution of dung and low contribution of firewood in Islamnagar is accounted for by the fact that Islamnagar uses cowdung cakes (besides firewood) for cooking. Animal energy contribution is 0.76% in Shilarwadi, 1.37% in Ungra and 2.93% in Islamnagar.

Commercial sources provide 5.42% energy in Islamnagar, 1.477% in Ungra and 2.04% in Shilarwadi.

Finally, human energy expenditures in Islamnagar, Ungra and Shilarwadi are 0.44%, 3.0% and 4.39% respectively.

The following are the observations/deductions of the study.

1 The hamlet of Shilarwadi has a population of 270 which comprises 76 men, 77 women and 117 children. 62 children are below the age of 5 and 24 adults above the age of 50.
2 There are 46 families (households) in the hamlet with an average family size of 5.86.
3 The total land in the hamlet is 161.5 ha out of which 26 ha is paddy land, 53.40 ha is cultivable waste land and 82.10 ha is uncultivable waste or forest land.
4 There are 16 families without cultivable land and 18 families without forest land. The average land/person is 0.598 ha.
5 The total land cultivated during 1980-81 is 26 ha of paddy and 12 ha of cultivable wasteland, i.e. total of 38 ha.

6 The total number of animals is 261 comprising 47 goats, 48 poultry birds, 81 cows, 49 draft animals, 9 she-buffallos and 27 calves. The cattle heads (without poultry birds) per person is 0.79 whereas draft animals/ha of cultivated land is 49/38 = 1.29.

7 The hamlet has 45 fruit trees and 101 other large trees. It uses very simple tools for agriculture, carpentry, fishing and hunting.

8 The agro-wastes essentially comprise paddy straw (775 kg/acre), Nachni straw (100 kg/acre) and Ambadi (2kg fibre/acre). For the land cultivated during 1980-81, their yields are: 50,375 kg of rice, straw, 30,000 kg of Nachni straw, and 60 kg of Ambadi fibre.

9 The domestic activities of cooking, fetching water, firewood collection for cooking and space heating, livestock raising, fishing and hunting require a human-hours input of 1,54,620 h of which 20.65% is provided by men, 41.15% by women and 38.2% by children. In terms of energy these activities require 23.79×10^6 kcal with 27.45% provided by men, 52.88% by women and 19.67% by children. The average rates in domestic work are 204.5 kcal/h for men, 197.8 kcal/h for women, and 79.2 kcal/h for children. All the domestic activities are dominated by seasonality.

10 The agricultural activity, which continues nearly throughout the year, requires 33,164 human hours of which 45.3% is provided by men, 43.04% by women, and 11.64% by children. In terms of kcal, the total expenditure of human energy is 8.53×10^6 kcal, of which 56.9% is provided by men, 36.93% by women, and 6.17% by children. The average rates are 325 kcal/h for men, 220 kcal/h for women, and 136 kcal/h for children. The premonsoon rab activity requires 23.6% energy, the monsoon period 39%, and postharvest operation 37.4% energy. The cost-intensive activities for men are harvesting and threshing whereas those for women are transplanting and harvesting.

In terms of human hours the peak months are July and August, followed by October and November.

11 The employment and trade activities require a total of 64,797 h out of which 54.87% is contributed by men, 24.75% by women, and 20.37% by children. In terms of energy, 18×10^6 kcal are expended, out of which 71.11% is contributed by men, 19% by women, and 9.88% by children. The average rates of work are: 360 kcal/h for men, 213.21 kcal/h for women, and 134.82 kcal/h for children. The most energy-intensive activities for men are forest cutting followed by forest-produce collection, whereas for women and children forest-produce collection is the most demanding.

12 The total human hours spent in domestic, agricultural and employment and trade activities are 2,52,581 h, out of which 32.66% is contributed by men, 37.18% by women, and 30.167% by children. In terms of energy 50.33×10^6 kcal are expended out of which 48% is contributed by men, 38% by women, and 13.95% by children. The average work rates are 293 kcal/h for men, 203.88 kcal/h for women, 92 kcal/h for children. These figures may be compared with 250 kcal/h, 200 kcal/h and 120 kcal/h respectively that are typically assumed.

The domestic activities consume 61.21% of total human hours, followed by 25.65% in employment and trade and 13.13% in agriculture. In terms of energy, 47.26% is spent in domestic activities, 35.76% in employment and trades and 16.95% in agriculture.

In terms of seasonality, April is the busiest month consuming 16% of the total human hours spent during the entire year. The leanest month is July when only 4.69% of total human hours are spent.

13 The energy source – activity matrix demonstrates that the total energy expenditure from all sources (i.e. human, animal, firewood, straw, grass, dung and food) is 1122.43×10^6 kcal per year, or 11390 kcal/capita/day. Out of this, 41% is provided by firewood, 27.3% by grass and shrubs, 10.18% by food, 9.61% by dung, 4.39% by human beings, 2.89% by rice straw, 2.04% by kerosene, and only 0.76% by draft power of animals.

Among systems, 38.72% of all energy is consumed by agriculture, 29.26% for domestic purposes, 18.5% for animal raising, 10.18 by human beings and 1.57% for employment and trade.

14 Firewood contributes 89.14% to domestic life (equally shared in cooking and space and water heating), kerosene for lighting provides 6.9% and the remainder is provided by human energy.

15 Agriculture receives 38.65% energy form firewood, 32.64% from grasses, 24.81% from dung and approximately 1.92% each from human energy and animal draft-power.

16 Animal raising activity uses 79.32% from grass, 15.6% from rice straw, and 5.08% from human energy.

17 The energy flows between systems show that the pasture lands and forests provide 785×10^6 kcal out of a total of $1122\text{-}43 \times 10^6$ kcal used in the total system, or 69.94% of total energy. This shows how strongly the human life is dependent on the natural ecosystem. The ecosystem also provides income worth Rs.52,952

and employment worth Rs.12,000 per year. In addition, this system provides 2100 litres of water per day.

18 The output/input ratio for human energy in Shilarwadi is 0.4326, for animals it is 0.5676, for agriculture 0.3144 (considering only the grain output) and 0.8142 (considering grain + fodder output).

19 The total energy/capita/day in Shilarwadi is 11.39×10^3 kcal, 19.75×10^3 kcal in Ungra, and 21.67×10^3 kcal in Islamnagar. The food energy consumption in Shilarwadi is 10.18% of total (1637 kcal/day/adult male), 19% (5148 kcal/day/adult male) in Ungra and 17.66% (5801 kcal/day/adult male) in Islamnagar. The yield rate of paddy in Shilarwadi is 350 kg/acre, in Islamnagar 446kg/acre and in Ungra 808 kg/acre. Thus agricultural production in Shilarwadi is very low. The large production rates enable Islamnagar and Ungra to export grains. In all villages, a major portion (between 75% and 85%) of energy is provided by firewood, straw, grass and dung.

20 Shilarwadi shows a particularly poor utilisation of animal power. This is partly because only 1.29 animals/ha are available which entails hiring animals at exhorbitant rates. This in turn reduces food consumption since repayments are usually made in terms of grain.

CONCLUSIONS

Overall, our assertion that Shilarwadi greatly depends on the ecosystem comprising pasture land and forests is confirmed by the energy utilisation pattern determined in this report. That the people of Shilarwadi live a life of depravity is also confirmed. Their agricultural productivity is low, which results in low food energy intake. The animal assets are also of poor quality mainly because of lack of availability of fodder. This results in both poor utilisation and indebtedness. Because Shilarwadi has no industry, it suffers also from lack of employment. Since there is shortage of water (in spite of 3500 mm precipitation) a second crop is not cultivated, resulting in poor utilisation of land, and unemployment.

Future work will attempt to extrapolate the data on Shilarwadi to the entire Karjat Tribal Block taking into account the trade and industry related activities in the 46 main villages of the block. Such energy consumption patterns will enable search for technological alternatives based on prioritisation of human needs and assessment of available resources.

REFERENCES

1. Gupta, C L (1979). Domestic Energy Consumption in India. Tata Energy Research Institute, New Delhi.
2. Jodha N S, Asokan M & Rajan J G (1971). Village study methodology and resources endowments of selected villages, Occassional Paper No. 16, Economic Programme, ICRISAT, Hyderabad.
3. Kulkarni, P U Trivedi, UV & Jain, B C (1979). Report on Jyoti Rural Energy Centre – a Preliminary Study. Energy Div, Jyoti Ltd., Vadodara.
4. Maheswari, R C *et al.* (1981). Energy Census and Resource Assessment of Village Islamnagar in the District of Bhopal. Central Inst. of Agricultural Engng., Bhopal.
5. Ravindranath *et al.* (1980). An Indian village agricultural ecosystem-case study of Ungra, *Proc. Energy from Biomass conference, Brighton,* UK.
6. Revelle, R (1976) Energy use in rural India, *Science,* 969-75.