ENERGY FOR SUBSISTENCE

MARGARET HASWELL

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Also by Margaret Haswell

ECONOMICS OF AGRICULTURE IN A SAVANNAH VILLAGE
ECONOMICS OF DEVELOPMENT IN VILLAGE INDIA
NORTHEAST THAILAND: 'Farm Gate' Surveys of Organisational and Financial Constraints on Development of the Marketable Surplus
THE CHANGING PATTERN OF ECONOMIC ACTIVITY IN A GAMBIA VILLAGE
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Contents

List of Figures

List of Tables

Preface

It is the current policy of governments, international agencies and aid organisations to try to find means of correcting growing imbalances between rich and poor nations, rich and poor within cities, and rich and poor between town and country. Yet, we, 'the common man', in the face of increasing shortages of the fossil fuels which support our food-systems, are reluctant to sacrifice our high standard of living for the benefit of those who continue to remain dependent on human energy for a meagre livelihood. Durnin and Passmore's *Energy, Work and Leisure* assesses for the prosperous industrialised nations human energy capacity by means of the rates at which we expend energy in our occupational and leisure activities. For the less-developed nations Norgan, Ferro-Luzzi and Durnin have made measurements of the human energy expenditure of subsistence farmers in Papua New Guinea. In this book these sources have been consulted in applying rates of energy expenditure to my measurements of the occupational and leisure activities of subsistence farmers in The Gambia.

Unique in my case has been the opportunity to make repeated studies of the same area, first in 1947–50, again in 1962 and 1973, and in May 1979 while in The Gambia as a delegate presenting a paper at the West Africa Rural Technology Meeting organised by the Food Production and Rural Development Division of the Commonwealth Secretariat, under the Directorship of Mr M. S. O. Nicholas, and the Government of The Gambia. The book should have wide applicability for research workers, teachers, policy-makers and practitioners, in the field of social and economic development.

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M.R.H.

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1 The Adaptive Phenomenon to Variable Amounts of Food Intake by Peoples Exposed to Extremes of Human Energy Requirements

For industrial uses man has been able to harness one source of energy after another from the wind to the atom; but for the type of energy that is needed by life itself he is still wholly dependent on the most primitive source, that of the animals and plants around him.

A major factor in the evolution of a complex human society has been the ability of a small number of individuals to supply the food requirements of a much larger number of people; but the systems which have been devised to feed these societies are fully dependent on sources of energy 'external' to the energy expended by the human beings which 'guide' them, and affluent societies are already beginning to consider themselves as poor, now that world energy resources are no longer capable of maintaining them at the level to which they have become accustomed.

Since energy is the crucial scarce resource in some form or another in all agricultural systems of the less-developed countries, the role of energy in *agriculture* has a direct bearing on the world food situation, which places the agricultural industry of these countries in the forefront of policy and planning.

Traditionally, agricultural practice has constituted a way of life in which relatively isolated rural peoples have had to adapt their cycle of economic activity to the cycle of the seasons, and accept as normal a pattern of abundance and shortage in their food supplies according to the vagaries of the climate over which they have had no control.

Many such societies have had to, and still do, depend on a large part of their population being directly involved in food production. The source of energy is invariably solely that of human labour, but two low-intensity forms of additional energy may be applied in particular environments: water and wind, and the use of animal labour.

It is an old peasant saying in the Western world that the 'horse eats people' which attests to the economic awareness of villagers that the maintenance of draught animals greatly cuts into the net output of a peasant's enterprise. The producer who farms for subsistence in today's less-developed countries however has a different viewpoint. He is concerned with inputs of *human* energy so often heavily constrained by the poor health status of the community in which he lives; and since the energy inputs of animals are a human-energy-saving factor, it is the energy-equivalent of the work done by animals that matters and not the energy required to support them. It is only when the final output of animals consists, as it does in the economically developed countries, of meat and milk rather than of crops produced by their draught power, that the energy required to support them matters because it consists of the food eaten by the animals. The most important factor behind the high energy intensity of agriculture in industrial countries is clearly their levels of meat consumption, not their levels of mechanisation.

Energy Availability

Any movement from one stage of economic development to another requires not only a catalyst but also a large reserve of human energy to enable communities to take advantage of it. The question which arises is whether there is any such saving where communities devote the greater part of their energies to subsistence; and while the energy value per unit of edible portion of subsistence foods may be relatively high, especially in cereal-based diets, their adaptability to soils of low fertility may nonetheless result in yields which give only a low return per unit of area and of labour input. The basic positive natural disadvantages of many tropical soils, and the uncertainty of rains, set very narrow limits of subsistence agriculture patterns of production. The variability in distribution and unreliability in total precipitation of rainfall, and the stormy conditions under which it frequently occurs further causes serious loss through run-off and consequent non-availability to the crop. Kowal,[1] studying the surface run-off and soil erosion from cultivated areas of gentle and long slopes at Samaru in Northern Nigeria, found that out of an average of 85 rainy days in the wet season 32 rainstorms produced run-off while the water from only 53 rainstorms was wholly accepted by the soil. The quantum and timing of rainfall at or before sowing determine the success of sowings, and quite minor periods of water stress can have very serious effects on yields under dry farming conditions.

Subsistence agriculture dominated farm family households tend towards a certain stability in the areas sown to crops from year to year based largely on their customary level of consumption; and while the overall calorie gap may be small for the whole population, it is important to know how far calorie needs are met within particular households and for particular individuals. Foodgrains are not only the largest source of human

TABLE 1.1 The energy value and nutrient content of some common subsistence foods

	Values per 100 g of edible portion					
	Rice, lightly milled (Oryza sativa)	*Bulrush millet, whole grain* (Pennisetum americanum)	*Finger millet, whole grain* (Eleusine coracana)	*Sorghum, whole grain* (Sorghum *spp.*)	*Findi, whole grain* (Digitaria exilis)	*Cassava, fresh* (Manihot esculenta)
kcal*	354	363	336	355	330	153
Water(g)	12	12	12	12	10	60
Protein(g)	8.0	11.0	6.0	10.4	7.7	0.7
Fat(g)	1.5	5.0	1.5	3.4	1.8	0.2
Carbohydrate(g)	77	69	75	71	71	37
Fibre(g)	0.5	2.0	3.0	2.0	6.8	1.0

*Derived by applying factors of 4 kcal/g of protein, 9 kcal/g of fat and 4 kcal/g of carbohydrate.
Source: B. S. Platt, *Tables of Representative Values of Foods Commonly Used in Tropical Countries* (London: HMSO, 1962).

energy supply, but are also the largest source of protein supply which is essential for body growth and maintenance (see Table 1.1); and most people suffering from calorie deficiencies also suffer from protein malnutrition, since the protein in the diet will be partially diverted to meet shortfalls in calorie needs. Where, however, a diet consists predominantly of starchy roots like cassava the concentration of protein is low and its quality of much less value to the human body.

Kowal and Kassam[2] observed that the vegetation cover of the Sahel reflects more than anywhere else the extreme severity of climatic constraints. In pointing to the importance of animal production as a supplementary source of subsistence foods where arable production is at high risk they note the low average yield of pasture in the southern Sahel of about 1300 kg/ha, and show the following pattern of growth of 2 to 2.5-year-old Zebu cattle:

August–September	daily weight gain 900 g
October–December	daily weight gain 400 g
January–June	daily weight *loss* 170 g

indicating the inevitability of losses in weight of cattle during the long dry season in the absence of supplementary feed, particularly protein. The main constraint here is the seasonal fluctuations in herbage quality and quantity in the natural savanna.

Energy Utilisation

Durnin and Passmore's *Energy, Work and Leisure*[3] is an important guide to the rates at which the human body utilises energy. It is, however, directed at the prosperous industrialised countries, particularly America and the continent of Europe, where there has been an enormous increase in recent years in information on rates of energy expenditure at work, in the home, and during recreation.

Many new sources of power have become available to these countries with the result that men and women use their muscles less and less in carrying out their daily work and in transporting themselves from place to place. The consequential changes in the life-style of the peoples of the industrialised world have, Durnin and Passmore observe, contributed to widespread obesity, and they suggest that a minimum amount of physical activity is required for health.

To allow for variations in body weights of men and women in different societies, the base figure in estimating human energy requirements is expressed in kilocalories (kcal) per kilogram (kg) of body weight. The Food and Agriculture Organisation of the United Nations (FAO) has, because of its responsibility in advising and assisting governments of member nations with the drawing up and implementation of agricultural policies, set out allowances of Calories which would meet the physiological demands for energy of men and women at all ages. The basis of their calculations is the 'reference man', free from disease and physically fit, weighing 65 kg and living in a temperate climate at a mean annual temperature of 10°C, and similarly a 'reference woman' weighing 55 kg. Since variations in body weights occur at different levels and intensity of activity, the FAO Committee has sub-divided the total daily energy output as can be seen from Table 1.2.

The way of life of subsistence farmers living in a tropical environment has been observed to be moderately active by Norgan *et al.*[4] suggesting that a realistic approach to an estimation of energy output would be to apply a figure of 45 kcal per kg of body weight to both men and women to any population displaying similar characteristics and environmental conditions: this corresponds closely to the FAO's 'moderately active' men and 'very active' women whose working day is usually longer. The effects of climate on the working *efficiency* of men and women is

TABLE 1.2 Energy output of the FAO 65 kg 'reference man' and 55 kg 'reference woman' according to level of activity

	Males (kcal/kg)	*Females (kcal/kg)*
Light activity	42	36
Moderately active	46	40
Very active	54	47
Exceptionally active	62	55

Source: Energy and Protein Requirements, Report of a Joint FAO/WHO *Ad Hoc* Expert Committee (Rome: FAO, 1973) p. 29.

however minimised by Durnin and Passmore who stress that far more important in determining food requirements in the tropics is the effect of climate on *activity*, though reduced activity may not be due to climate but to the effects of poverty and ill-health. In fevers, for example:

> resting metabolism is raised: in typhoid fever it may be increased by more than 40 per cent. The rate rises by about 7 per cent for every degree Fahrenheit rise in body temperature (11 per cent/°C). The increased heat production is the result of toxins produced by the infecting organisms but how these stimulate metabolism is not known. The increased energy output in all febrile conditions justifies the old adage 'feed fevers'.[5]

Typhoid, dysentery and cholera, diarrhoeal disease and other intestinal infections, are spread through contamination of food, water or soil with human waste, not only causing much illness among adults but often proving fatal to infants or undernourished children; and just as malnutrition can increase susceptibility to disease so also can disease contribute to malnutrition. Epidemics of diarrhoeal disease are often followed after a few weeks by outbreaks of nutritional diseases. Enteric infections inhibit the absorption of nutrients in the intestinal tract thereby increasing the intake required to maintain nutritional status, while fevers associated with infections increase the role of metabolism so boosting nutritional requirements.

Fresh water is essential for life, and the water requirements of draught animals may, and frequently do, compete with those of man; even so fresh water is rarely available in quantity either to man or beast in subsistence economies. Yet water development for agricultural purposes may actually worsen health, exposing whole populations to disease in the course of farming irrigated lands. Increasing the area of above-ground water has been found to enhance the population of malaria-carrying mosquitoes in rice fields: house entry rates have also risen alarmingly in non-irrigated regions where human populations have settled in villages at the periphery of such development schemes. Human health problems in rural areas of the tropics are further exacerbated by the instance of *schistosomiasis*, or bilharzia as it is commonly known. The snail vectors of *schistosomiasis* are associated with sluggish waters and these may either be natural or man-made. One of the most important clinical manifestations of this disease is anaemia, the debilitating effect of which seriously affects the productivity of the agricultural worker. Chronic and acute disease not only affect the human being as an economic resource in his capacity as a supplier of labour but also his capacity to organise, plan, adapt and innovate; and high rates of infant mortality coupled with low life expectancy, which are the inevitable consequences of the poor health status of rural populations exposed to these hazards, distort the structure of the economically active age group and strongly influence social behaviour and psychological attitudes towards life, work and leisure.

Seasonality in Agricultural Production and the Role of Women

The family in farming has long been a controversial subject in Western Europe and the United States, many claiming that the family farm constitutes a desirable tenure pattern: but none would expect that such holdings should be self-sufficient in the goods and services consumed in the household or even in most of its food. However, in a study of labour use on family farms in England, the author found the income received per hour of family labour, towards which each farmer had contributed a large share of the manual work, to be equivalent to no more than a subsistence wage. The availability of 'cheap' labour from within the family unit and the absence of high rents made it possible for family farmers to continue in business at a low level of productivity and at the same time keep labour wastefully tied to the farm.[6] Farming, although it proved to be for only a subsistence living, was an all-the-year round occupation, the pattern of production being mixed livestock enterprises, principally dairying, and crop enterprises, principally for cattle feed: two-thirds of the human energy expended was on livestock enterprises, which extended the time pattern of production.

Durnin and Passmore quote studies of traditional European farming dependent on man-power in Hungary (1932), Russia (1933) and Italy (1945) to show 'that peasants do much work involving *moderate* and *heavy* physical activity. Peasant farmers in Africa and India also do *heavy* work'.[7] They refer to dairy work, even milking by hand, as being mostly *light* work, requiring an energy expenditure in the range 2.5–4.5 kcal per minute (Tables 1.3 and 1.4).

For the subsistence-tied rural masses of less-developed regions of the tropics however, study of the rates at which the human body utilises energy leads to the substitution of

TABLE 1.3 Energy for subsistence: case studies of the family in farming in England

	Average hours worked per year	*Estimated annual energy expenditure kcal ('000)*
Human labour		
Male	2807	674
Female	780	159
		833
Animal draught power		
Horse	400	240
Mechanical draught power		
Tractor (65 hp):	353	
Fuel and oil		14932
Depreciation and repairs		4405
		19337
Total		20410

Source: M. R. Haswell, 'Labour Organization on Family Farms', unpublished B.Litt. thesis, Oxford University (1954).

TABLE 1.4 Energy expenditure in traditional European farming dependent on hand-labour

Activity	*kcal/min*
Mowing with a scythe	5.6–10.2
Binding sheaves (men)	6.2–8.6
(women)	3.0–4.9
Stooking sheaves	5.1–8.4
Loading sheaves	5.0–6.5
Threshing, various tasks (men)	4.2–6.0
(women)	3.8–5.5
Ploughing	5.2–7.8

Source: Durnin and Passmore (1967) p. 66.

TABLE 1.5 Energy expenditure in subsistence agriculture in the tropics

Activity	*kcal/min*
Africa	
Grass cutting	4.5
Clearing bush and scrub	5.8–8.4
Hoeing (women)	4.8–6.8
Weeding	3.8–7.8
Planting groundnuts	3.1–4.5
Ridging, deep digging	5.5–15.2
Tree felling	8.4
Head panning, loads 20–35 kg	3.2–5.6
India	
Mowing	5.1–7.9
Watering	4.1–7.5
Weeding, digging and transplanting	2.3–9.1

Source: Durnin and Passmore (1967) p. 67.

lethargy for leisure (Table 1.5). For human energy is virtually the only source of power for a great majority and food availability is highly seasonal, with seasonal patterns in energy expenditure tending to pull in opposite directions to patterns of food intake. This is particularly so where a long dry season in which no agricultural production takes place is followed by a short wet season of labour-demanding agricultural tasks. Though calorie requirements during periods of harvest may be adequate and more than met for some so that fat is laid on the back, and a balance of intake over requirement roughly maintained by reducing physical activity as food stocks dwindle, the imperative of moderate and heavy work as the onset of the rains herald a new agricultural season finds many bearing the physiological burden of an energy-expenditure debt which has far reaching social, political and economic consequences: to this must be added the energy *cost* to a mother of producing a baby, and the extra kcal per day she must put out to provide the infant with milk during the period of lactation.

The seasonal nature of agricultural work is associated with problems of holding reserves of food to carry over from one harvest to the next and this is reflected in seasonal variations in levels of consumption. The harvest is an occasion for feasts. This is generally followed by leisure pursuits or low energy requirement non-agricultural activities, with a consumption boost at the beginning of the new agricultural season during heavy work load peaks. Then, as food stocks dwindle, fat stored on the back in earlier periods of feasting is used as a source of supplementary energy to help bridge the gap between requirement and availability of food until the next harvest is reaped.

It is interesting to observe from two detailed surveys undertaken by the author, one in West Africa and the other immediately following in England, that the *human* energy expenditure for the latter was only 4.0 per cent of total energy expended while that of the former was 100.0 per cent (Tables 1.3 and 1.6). However, despite the

TABLE 1.6 Energy for subsistence in an African Savanna village economy: the contribution of male and female labour

	Male	*Female*
Energy expended per farmer per working day (kcal)	1293	1277
Average number of days worked per farmer during the agricultural season	103	158
Average number of hours worked per farmer during the agricultural season	595	1073
Contribution to aggregate energy expenditure (per cent)	39	61

Source: M. R. Haswell, *Economics of Agriculture in a Savannah Village*, Colonial Research Study No. 8 (London: HMSO, 1953).

high-intensity application of energy as fossil fuel (almost 100.0 per cent, with that of draught power contributing only 1.2 per cent) the English family farmer was still required to put in many hours work; and indeed Lawton[8] points out in estimating the energy costs of farming in Britain that the energy cost of producing meat in particular must be very large because it involves energy expenditure at two levels rather than just one: that is in animal foodstuff production and animal husbandry. Even so the pattern of human labour use, though peaks and troughs occurred, extended throughout the year, while that of the West African labour was concentrated in a short, wet season: more importantly, at the low levels of subsistence which were recorded, was the full-time contribution of women in farming who worked almost twice as many hours as the men – though very similar results were obtained in terms of average energy expended per working day. By contrast the wives of family farmers in England at best gave only occasional assistance, while usually running a small-scale enterprise of their own – pigs, poultry and the like – to provide an independent source of cash income for 'luxury' spending. Human energy expenditure in farming under these conditions represents only a small proportion of human energy *consumption*, perhaps no more than 15 per cent, in a situation where family farmers, though their net income may have achieved for them no more than a subsistence wage, were not constrained by seasonal fluctuations in food intake. This low figure of energy expended in farming by housewives tells us nothing however about the ratio of energy *gained* over energy expended; that is to say, the efficiency of agricultural systems in Britain in turning human effort – so massively aided by fossil fuel energy – into food which, for subsistence cultivators in the tropics depending almost entirely upon their own efforts, is of such paramount importance.

Before proceeding to an examination of extremes of human energy requirements for subsistence in tropical regions, energy *values* must first be assigned on a daily basis according to age and sex with additional allowances for lactating mothers and the extra requirements for pregnancies. Appropriately, data on individual weights of males and females used in making these calculations is that of the author's 1962 re-survey[9] of the African community referred to previously, and on this occasion the population census was taken during the season of post-harvest relative food abundance; a mean daily energy output of 45 kcal per kg of body weight has been adopted for both men and women after taking note of the work of Norgan *et al.*[10] as mentioned earlier. Applying this figure to the average weight of the 20–39 year old population in January 1962, we arrived at a daily *requirement* for adult men and women as follows:

Male (average weight 58.82 kg)	2647 kcal per head
Female (average weight 51.56 kg)	2320 kcal per head

Requirements for other age groups have been derived from this statistic (see Appendix I).

Customarily communities of subsistence farmers in tropical regions divide agricultural tasks according to age and sex. It is when the unit rates and the proportion of time spent on various activities by men, women and children throughout a twenty-four hour day are computed however that an assessment can be made of the *utilisation* of energy.

For our African village energy expended for the subsistence component of activity is about 52 per cent of the daily requirement of adult males and 56 per cent of the daily requirement of adult females (compared with 53 per cent of the daily requirement of full-time family farmers in England). These estimates however take no account of the seasonal variations in agricultural tasks.

In arriving at a realistic set of values to enable the computation of energy expended in the various tasks involved in subsistence production, a number of relevant sources were consulted; appropriate values were then applied to the complete African village[11] data on hours worked by males and females throughout the agricultural season (see Appendix II). Rates of energy expended by

TABLE 1.7 Seasonal pattern in energy expended for subsistence in an African Savanna village economy, 1949/50

	Energy expenditure in kcal/farmer per working day		
Males			
	under 11	11–15	16 and over
May	528	558	842
June	1090	1197	1585
July	947	1417	1895
August	792	1074	1313
September	1041	1195	1299
October	764	921	1272
November	773	947	1092
December	756	856	1073
January	–	276	555
February	–	–	–
Females			
	under 11	11–15	16 and over
May	–	945	1049
June	–	1251	1646
July	–	1292	1537
August	–	1129	1347
September	–	1180	1433
October	–	870	829
November	–	843	793
December	–	863	1211
January	–	937	1282
February	–	–	1350

Source: Haswell (1953).

children in agricultural work are however virtually non-existent and these have therefore been estimated by calculating ratios derived from the requirement for children appropriate to their actual body weight *excluding catch-up* and relating this to the requirement for adults (see Appendix I). In the 1949/50 agricultural season human energy was the only source of supply. As soon as the first heavy rain fell in May all male members in the family old enough to work went to the 'food farms' to clear an area of savanna for planting with late millet, an energy-demanding activity (5.4 kcal per minute of work) conducted as a communal activity, for which the compound family head could call forth labour for no more than two to three hours work per day for a period of about a week;[12] planting, dropping the seed into holes made by the dibble-stick and covering it with the toe of the foot was a light task of short duration (3.4 kcal per minute of work). However, yields were poor and the greater dependence for the supply of foodgrains for subsistence fell upon the female members of the family. The women cultivated river flats for the production of rice, employing long-handled draw hoes as their only tool. In that women and girls were responsible for the rice production and rice by weight made up about 80 per cent of the total foodgrain supply, the female labour force of individual family compounds determined in large measure the choice of crops and food supply. Men in family compounds with a relatively large female labour force tended to devote less time than other compounds to millet production, concentrating their energies on growing groundnuts as a cash crop.

With human labour as the only input 'scarcity of season' was the over-riding constraint. Peaks of energy expenditure in June–July in the busy season soon after the rains broke and particularly during the first weedings demanded the expenditure of human energy on agricultural tasks alone of at least 70 per cent of the estimated daily requirement of both men and women, which implies the build-up of an energy-debt taking account of the energy requirements for the remainder of a 24-hour day. Wherever actual food consumption could not be increased by drawing on food stocks to meet these heavier demands loss of body weight occurred; for pregnant women and lactating mothers – about 15 per cent of the women between 15 and 44 years of age were estimated as being pregnant, requiring an additional 285 kcal per day, while the additional requirement for lactating mothers ranged from about 350 to 550 kcal per day depending on the age of the infant – the energy required for subsistence at this season severely aggravated already serious problems of health and nutrition in many households.

Non-Agricultural Activities which are Independent of Season

Particular constraints which women engaged in full-time farming face are the many activities required in the preparation of food: these must be relentlessly performed even during periods of high energy expenditure in the production of the staple food crop. Among the most demanding are the hand-pounding of foodgrains and fetching water from wells (see Appendix III). Although the high participation rate of women in subsistence agriculture leads to some reduction of these time-consuming other activities during peak periods of agricultural activities, more important is the increased pressure of work before going out to the fields in the morning and after returning at night, and the skimping or abandoning of many of the refinements which are undertaken at leisure at other times of the year. Pounding of foodgrains begins before daylight between 5 and 6 a.m. and women retire to bed between 9 and 10 p.m. after the evening meal (any 'left-overs' from which are taken to the field the next morning as snacks). When agricultural work is at its heaviest, child-care is entrusted to older girls between seven and eleven years of age and mothers are all too often unaware until it is too late when a young child falls sick.

The preparation of food also involves the collection of wood as the source of fuel for cooking. Makhijani and Poole[13] refer to the extensive use of wood in the Sahel region of Africa as probably one of the causes of the spread of the Sahara desert, and quote figures based on The Gambia to arrive at a per capita annual consumption of about one metric ton: that part which is used for cooking in rural areas on low-efficiency open slow-burning fires has been estimated at 1.2 kg per head per day, a figure which Makhijani and Poole note is comparable to cooking energy used in rural India; likewise a small rural village in the dry zone of Sri Lanka was found to have a firewood consumption of 1.5 kg per male adult unit per day, of which about 80 per cent was for cooking.[14] This routine activity which is independent of season is the only one in which men participate, and while in the early post-Second World War period wood was relatively plentiful and dead or dying trees were cut down for this purpose, it has since become an increasingly scarce commodity: seeking an adequate supply is an ever more time-consuming occupation. 'Women in the poorer households who cannot afford charcoal shift from wood to cow dung, tree bark, dried maize or millet stalks. With water however there is no substitute. A combination of distance to a source of clean water and family size will influence the number of trips made for water.'[15] Young girls will headload 1½–2 gallons per trip while older women will carry 3–4 gallons: drawing water and its porterage are energy-demanding activities especially where wells are deep as in The Gambia. During the agricultural season, particularly at the critical time of planting, trips are made in the evening only and gallonage little more than one per person in the household – far below the daily needs for drinking, cooking, washing and personal hygiene, exacerbating problems of fatigue, weakness and weight loss, caused by water depletion where communities are subsisting in a hot climate. Heat exhaustion and water debt severely limit the energy output of agricultural workers.

Activities Performed Outside the Agricultural Season

The West African Savanna of the late forties supported a vegetation typical of fire climaxes consisting of mixed formations of grass and fire-resistant trees and shrubs; and once upland crops were reaped cattle were free to browse for grazing herded by boys and young men. At this date, however, arable farming was the principal activity of the village area under study and cattle were owned and handled by a different tribe as was customary. Tending domestic animals was therefore of negligible importance and confined to the care of a few sheep and goats.

Most of the Savanna was allowed to revert to bush fallow for a number of years after only a few years cropping, but towards the end of the dry season land intended for planting with the new season's millet was cleared of the smaller trees (except for those of economic value for the fruits, berries and leaves which they seasonally produced) and of all secondary bush growth and scrub by means of axes and fire; this was the season for hunting by men and boys as they gave chase to wild animals driven out by the flames. Marketing similarly was a negligible activity being solely that of disposing of the cash crop, groundnuts, grown for export, when the men sold their nuts unshelled to the trader at the nearest buying point.[16] Otherwise trade was confined to the occasional barter of local products.

The period of intense activity during the farming season between May and December was therefore followed by a long period of inactivity which was forced upon households not simply or even necessarily because the dry season offered no alternative occupations, but in response to the level of food in their stores from one month to another to carry them through to the next harvest. Rain fell between late May and the end of October and it has been observed by Gamble that during the latter part of the dry season between March and May there were a number of changes in the quality and quantity of food eaten which indicated a chronic food shortage. Gruel, which uses less grain, was served with greater frequency and even bran was used in cooking, and by August there were a number of families who were not getting even one cooked meal a day but were living on boiled leaves and groundnuts.[17] Gamble observed that on such a diet women were collapsing from too much work and too little food as they returned from the fields – the latter part of August being the time of severest hunger. Table 1.8 illustrates the extent of the problem for a sample of households where surveys were repeated at approximately eight-weekly intervals showing that even the highest value recorded for Calorie intake between June and August was below the energy requirements calculated for adult males aged 20–39 (Appendix I). Clearly, body weights were well below the average 58.82 kg of the 20–39-year old population in January 1962 upon which the daily requirement figure of 2647 Calories has been based (see p. 14). On the other hand consumption in the December–February period following the harvest was for many well above the daily requirement figure, allowing for feasting and fat to be laid on the back; and it is from among those whose consumption is adequate and more than adequate to meet energy requirements that the main off-season relatively energy-demanding activity of house building between March and May is performed.

For the majority this is a season of maximum

TABLE 1.8 Seasonal pattern of Calorie intake in an African Savanna village economy, 1948

	Seasonal mean	*Highest value recorded* (*kcal per head per day*)	*Lowest value recorded*
Dec.–Feb.	2167		
(Jan.)		3243	
Feb.–Jun.	1653		
(Apr.)			1232
Jun.–Aug.	1747		
(Jun.)		2479	
(Aug.)			1088
Aug.–Dec.	1502		
(Oct.)			1083
(Dec.)		2664	

Source: M. R. Haswell, *The Nature of Poverty* (1975), pp. 101, 103.

conservation of energy: just for sleeping and sitting around all day an energy requirement of some 1500–1600 kcal is still needed by the average adult, and while it is apparent that the extremely low recorded values shown in Table 1.8 at the bottom end of the scale do not reflect the consumption of leaves, roots, berries and fruits eaten by men, women and children while away from the homestead, the gap between consumption and energy requirement is nevertheless far from closed by reliance on 'food gathering' to supplement seriously depleted stocks of foodgrains for a large number of people subsisting under a system of slash-and-burn hand-hoe agriculture in the Savanna of West Africa.

2 The Case History Material: a Rural People in a Tropical Environment

'Few Gambians can locate Genieri on the map' wrote Jay Saidy in 1976.[1] 'Even fewer know what great potential that tiny Eastern Kiang village once had for a social, cultural, and economic breakthrough only three decades ago.' Yet it does provide case-history material unique of its kind which in the current state of knowledge can be used as a laboratory for analysis of energy for subsistence.

In 1947 the Human Nutrition Research Unit of the Colonial Medical Research Council sent a team of research workers out to The Gambia in West Africa to make a survey of health, food consumption and production, sociology and economics centred on Genieri village which is located on the south bank of the Gambia River 190 kilometres upstream. The author was the agriculturist member of this field working party and, in 1949, after two years of sample inquiries, she exhaustively evaluated both the human population and food production for the village as a whole.

By custom and as a result of the spread of Islamic culture the people of Genieri are a polygamous society, and in the early post-war period the extended family system was strongly entrenched within the compound structure. Each compound contained a number of huts made of bamboo stems sliced into long strips woven into a loose matting and plastered with mud to provide walls, and roofed with a grass thatch. The aggregate of huts within the compound were separated from their neighbours by a fence of bamboo lashed to stakes of a termite-resistant wood. The records of output in the first year of inquiry revealed the extremely low yield base of even the suitable crops because of the variability and poor distribution of the rainfall which occurred during a well-defined short wet season lasting from the beginning of June until mid October.

Traditional Farming Practice

As has already been described, in this 1947–50 period work on the various crops grown was sharply divided between men and women.

Mangrove forests consisting of *Rhizophora racemosa* and *Avicennia africana* lined the bank of the Gambia River. These gave way to open stretches of annually flooded grassland. Salt-resistant grasses covered large areas; at intervals, *Phragmites communis* was the dominating cover. There was evidence of very uneven and extremely poor drainage. In an area which may at one time have been a strip of fringing forest along the river edge, the fan palm *Borassus aethiopum* or the Rhun palm (by which name it was locally known) was found in proximity to the swamp. This gave way to degraded 'Guinea savanna' which, it was estimated, had been farmed at periods varying between fifteen and fifty years. Most of the common West African Savanna species were to be found, of which Acacias were particularly numerous as was the so-called Rosewood *Pterocarpus erinaceus*, suitable for making furniture for village use; bamboo thickets *Oxytenanthera abyssinica* were found forming an understorey to larger savanna trees but their growth was poor. Soil types were found to be closely associated with topography and the change from one to the other was clearly defined.[2]

The axe and cutlass were the only tools employed by male members of the household clearing or 'brushing' the savanna areas preparatory to planting the foodgrain millet between the tree stumps in depressions made with the long-handled flat-bladed hoe (or dibble stick). These 'bush' farms were some distance from the village and required a long period of bush regeneration after only three or four years cropping before they were considered worth bringing under the hoe again. Of importance to the human population were the wild products which could be collected to supplement diets or as a substitute in times of food shortage. However, the long walk to the area of these 'bush farms' has to be seen in the context of the poor quality generally of these Guinea Savanna soils which were extremely low in organic content, deficient in phosphorus and calcium, and tending to acidity. The better-drained soils were ochre-brown sandy loams in the vicinity of the village itself and these were entirely taken up with the cash crop, groundnuts, grown in rotation with the 'famine' food '*Digitaria exilis*'. The groundnuts were lifted, winnowed and stacked on the haulm leaving no crop residue in the soil, and from this time until the commencement of the following year's rain the soil was left without cover and subjected to intense heat from the sun. Above the ironstone escarpment the practice of 'shifting cultivation' for millet production included that of leaving trash uncleared after the harvest until shortly before the onset of the new rains when brushwood was gathered into heaps and the bush fired. The process of harvesting millet was to flatten the stems, which grow to a considerable height, with the ripening heads pointing in the same direction and leaving them lying for up to a week for sundrying. The next stage was to cut at the neck those heads which had ripened and tie them into bundles; because of the uneven ripening it was possible to head load one or two bundles each day when returning to the village after work thereby reducing or even eliminating the need to make extra journeys at the end of the harvest simply for the transport of the product. Once back in the compound the bundles were stacked unthreshed on bamboo platforms in the yard for further sundrying and later transferred to covered storage – raised bamboo structures with a grass thatch – before the rains started. Late millet was the foodgrain most suited to the region because of its greater dependability in seasons of short-duration rainfall and its yield ability on sandy and less fertile soils: this bulrush variety of pearl millet *Pennisetum typhoides* is an awned variety which partially protects the grain from bird damage, a hazard which limited the production of early millet, the bare seeds of which were a favourite of many birds, to plots immediately adjacent to compound households where children could be employed bird-scaring.

Maize was also cultivated solely as a minor or compound food crop but for a different reason. In soils which were deficient in phosphorus its production was dependent on compound refuse thrown out by the women and the dung of domestic animals, sheep, goats and fowls kept in the yard. The rate of mortality of these small livestock was high, fowls constantly being carried off by birds of prey, and sheep and goats hard to rear especially during the rains. Their value was largely one of social prestige, and those that reached maturity were usually killed for ceremonies and feasts. Maize was almost entirely eaten green as soon as the green crop matured in August at the time when food stocks and Calorie intake were at their lowest (Table 1.8). The relatively high ratio of energy gained to energy expended on these minor early-maturing crops arises from the 'garden' nature of their production – tiny plots upon which minimal effort was applied in the expectation of some return to help tide the family over while waiting for the main foodgrains, late millet and rice, to be ready for harvest.

Rice was grown by the women as an upland rainfed crop and as a flood-irrigated swamp crop; because the Gambia River is salt in this region for part of the year, Genieri farmers could only grow one crop per year and that during the rainy season. Farther up river where there are no salt inundations there exists the potential for two crops annually, a rainy season crop and a dry season irrigated crop, though at this period of investigation double-cropping was not practised anywhere within the country. The hand-hoe was the only tool employed for the cultural operations and locally-made knives were used for harvesting the paddy rice. The harvested paddy was then left in the field to dry for up to one week, after which it was transported by head porterage back to the compound households and stored on the stalk unthreshed. The women took out a bundle or two as required for consumption, hand-pounded the grain to remove the outer husk, and winnowed off the inedible portions to produce the clean rice. Paddy on the head, the most resistant of the cereal grains to insect pest, was stored in small round huts thatched with grass similar in style to the human habitations, and for extra protection against infestation animal dung was mixed with the mud used to plaster the walls of bamboo splits.

Time-Budgets in the Farming Population

Lawton summarises the energy costs of 'food-gathering'[3] for a human society operating in essentially the same way as five other types of animal – the dragonfly, the large-mouth black bass (a fresh water fish), the tropical hummingbird, the bumble bee, and the dickcissel (a north American finch). All the work of harvesting and catching food was carried out entirely by human labour and there was no external energy subsidy of any kind. 'The most interesting thing from the point of view of an animal ecologist,' states Lawton, 'is the remarkable similarity between the ratio of energy gained to energy expended (18.4) in this simple human society, and the same ratio for the five types of animal.'[4] His 'food-gatherers' were the Lamotrek Atoll islanders in the Pacific who harvested the tree crops of coconuts and breadfruit, planted taro (a rootcrop), kept pigs and fished for turtles and sea-urchins.

Of interest is the surprising similarity in the ratio of energy gained to energy expended when one considers the large differences in the demands which the energy surplus generated in foraging has to meet in the different species (including mankind) – a point which is well made by Lawton. However, the critical question which he poses is 'How can an animal increase its net energy gain during feeding assuming that this is a desirable objective?' Lawton suggests three ways of doing so:

(1) By spending more time food-gathering at a more or less constant efficiency. This is only a practical solution provided that the time required does not conflict with other essential activities like sleeping, courtship or avoiding predators.
(2) To spend the same time food-gathering, but to increase efficiency; but the problem here is what constitutes, energetically, the most efficient searching rates in active food-gatherers.
(3) To allocate the time spent foraging so that proportionally more is spent in areas of high food-energy availability.

Given that these somewhat severe restrictions operate for 'food-gatherers' are there wider choices available to communities practising hand-hoe agriculture? The author indicates for women rice cultivators in Genieri that the different rates of energy cost for each cultural operation are compensated for by the time spent resting in the field. The net effect of this is to hold more or less constant the energy cost per unit of time of all agricultural tasks involved in the production of rice.[5] Clearly this solution prolongs the time taken to undertake the more energetically expensive tasks such as hoeing heavy clay soils prior to transplanting rice seedlings for which activity the time spent resting was 41 per cent, compared with only 9 per cent when performing the relatively light task of harvesting. This method of resolving energy needs adds a further dimension to the problem however, that of the time constraint imposed by scarcity of season during which a particular task can be undertaken. Traditionally it is the

TABLE 2.1 Summary of the ratios of energy gained to energy expended in subsistence farming, Genieri village, 1949/50

Crop	*Per cent of total area cultivated*	*Ratio of energy gained to energy expended* a	b	*Per cent of total human labour energy costs*
Guinea savanna grey soils				
(above scarp)				
Late millet	12.0	8.1	10.9	7.2
Grey soils and ochre-brown sandy loams				
(below scarp)				
Early millet	1.8	12.4	12.4	0.9
Sorghum	1.7	13.9	15.1	0.4
Digitaria exilis	11.3	16.8	18.2	1.3
Maize	0.8	13.4	13.4	0.8
Groundnuts	35.5	14.7	15.6	28.1
River flats				
Upland and swamp				
Rice	36.9	5.3	6.1	61.3
Net-energy surplus overall		**8.4**	9.6	

[a]Including walking to and from farm plots.
[b]Excluding walking to and from farm plots.

combination of these two factors which has strongly motivated societies to organise their resources in human labour by allocating clear cut functions specifically to men or women and also to divide many of the tasks according to age–sex groupings.

The summary of ratios shown in Table 2.1, however, call into question the utility of traditional systems of labour organisation where energy gain over energy expended falls so far short of Lawton's 'animal kingdom'. The high cost borne by the women cultivating rice for home consumption is solely explicable in terms of survival and has no economic rationale. The fact that almost a fifth of the labour force was under 16 years of age (see Table 2.2) is also indicative of the existence of pressures to guarantee food security. The energy demands made upon children were however light, ranging from 22 to 45 per cent of total daily energy requirement; for example, 59 per cent of all hours worked on early millet were occupied in bird scaring and of this activity 98 per cent of the time was spent resting in between sudden spurts of 'scarecrow' activity. Rice was similarly affected by bird

TABLE 2.2 Age and sex distribution of farmers in Genieri village, 1949/50

Age	*Males* (%)	*Females* (%)	*Both sexes* (%)
Under 11	4.3	–	4.3
11–15	8.4	5.6	14.0
16–19	7.4	4.0	11.4
20–39	19.2	31.9	51.1
40–49	6.8	5.6	12.4
50 and over	2.8	4.0	6.8

Source: Haswell (1953).

TABLE 2.3 Human labour utilisation in subsistence farming

	Days[a] (%)	*Hours/day*[b] *worked* (%)	*Peak periods of activity*
No external energy subsidy: Genieri village, 1949–50			
Male farmers			
0–10 years	38.0	63.5	No obvious peak
11–15 years	38.2	73.9	June
16 and over	46.2	72.6	July and October
Female farmers			
11–15 years	45.2	93.7	May, June
16 and over	70.1	84.4	May through Sept./Dec./Jan.
Assisted by energy supply available as animal power and fossil-fuel: Family farm case studies, England, 1953			
Male farmers	100.0[c]	117.0	Year-round mixed livestock and arable farming
Female farmers	100.0	32.5	

[a]Based on a 26-working day month over a nine-month agricultural season from May to January in tropical West Africa.

[b]Based on an 8-hour working day on those days worked.

[c]Based on a 300-working day year (i.e. 82.2 per cent of all possible days in a calendar year) under temperate climatic conditions.

damage and required many hours spent on bird scaring. Nevertheless the birds still managed to consume a considerable proportion of the standing ripening crop. Young adolescents between 11 and 15 years, on the other hand, were also called upon to assist their elders with a wide range of farm tasks, at times involving an energy expenditure approaching 50 per cent of their daily energy requirements. The adult population placed high value on the number of boys and girls in the farming community whose energies could be readily exploited under the social system extant at the time of extended family households. The joint FAO/WHO *ad hoc* Committee on energy and protein requirements sub-divided total daily energy output into three parts according to the time spent: (a) in bed, (b) at work, (c) in non-occupational activities, and assigned a value for the exceptionally active man or woman at work of 60 per cent of total energy expenditure over 24 hours. 'For individuals within occupations', the Report states, 'the variability in daily energy expenditure depends to a large degree on the activity undertaken in leisure time', but the exceptionally active occupational group 'probably inhibits active leisure'. That there was serious energy imbalance among adult women in farming in Genieri village is clear from the evidence that energy expenditure at work on food production exceeded 60 per cent of total daily energy requirement[6] by 10 per cent or more during the four-month period June to September (Figure 2.1). Though the energy demands at this critical season before the main harvest made upon children and adolescents under 16 years were light to moderate in relation to daily energy requirements, their contribution in terms of the time-pattern of production and the type of activities which were assigned to them was vital to the production unit.

Yet a labour utilisation of less than 50 per cent and an average of only 5.8 hours per working day over the whole agricultural season contributed by the adult male farmers indicates that there was surplus capacity. What other activities then were considered essential in the allocation of time? In the British example causes of high or low net family income per man-equivalent of family labour were due to the organisation or the management of the farm or both and also the capacity and efficiency of the family workers; but *social* factors were not exclusive, and there is no evidence to show that behavioural patterns differ greatly between one society and another dependent on the family in farming simply because the natural environment within which they subsist is far from comparable.

Dependency levels in the Consuming Population

If a self-supporting food-gathering community generates more energy than it expends during collection relying solely on the abundance of nature, no less must a subsistence cultivator in tropical Africa or the family farmer in temperate Britain: but while the family farmer in Britain can change his occupation (and there is considerable debate on the subject of consolidating small holdings and pension schemes to enable farmers on uneconomic units to be retired) or change his combination of inputs to achieve higher productivity, the subsistence cultivator in Africa has no such access to alternative employment and neither has he the necessary infra-structural support to enable him easily to diversify his resources in energy inputs, for example by low intensity applications of animal labour, water or wind, let alone by utilising the energy supply available as fossil fuel. The participation or activity rate of the farm family household is therefore of paramount importance.

A low dependency ratio in hand-hoe subsistence agriculture is deceptive however, particularly where the degree of family participation is large. In Genieri village in 1949, the dependency ratio per farm worker was 1.49:1, indicating that every man, woman and child able to cultivate was employed doing so compared with, for instance, urban-orientated farm family households in a Philippino settlement area of high productivity irrigated holdings accessible to a sizeable urban area, which had a ratio of 4.43:1; however where settlements were non-irrigated and remote from the infra-structural support services of a sizeable urban area, the dependency ratio per farm worker was observed to be 1.90:1 which is quite close to that of Genieri village in 1949.[7] The overall net-energy surplus in Genieri village (8.4) did not suffice for the maintenance of the total population however because it includes the energy gain over energy expended by male farmers on the groundnut crop (Table 2.1) which was sold for cash. This dependence of the men on the food production of the women significantly increases the dependency ratio for home consumption to 2.30:1, taking account of the energy expended by the men on production of the foodgrain millet. A mere 8 per cent of all hours worked was devoted to this crop, while 66 per cent of all hours worked and 61 per cent of the total energy was expended by the women growing rice for home consumption.

There is another aspect of dependency which should be noted; that of the unborn child and the child at the breast. Norgan *et al.*[8] make the striking observation among their New Guinean subjects that 'there was no difference in intakes between the pregnant and the non-pregnant non-lactating women. However, the women who were breast-feeding a child more than one year old had significantly higher energy and fat intake than the non-pregnant non-lactating women'. They agree that these results do not fit in with the recommendations of the extra requirements of energy for pregnancy and lactation. The intake of the women from the population studied in the highlands in the villages around Lufa was on average 'moderately high by most standards and there did not appear to be a deficiency of food: it was simply that when they became pregnant they did not eat more'. The way of life and general environment of the second of the two groups of people studied was, however, very different: Kaul was a conglomeration of four villages studied, located between the edge of a coconut plantation and moderately open jungle on Karkar, a fertile volcanic island. 'In Kaul', they observed, 'it was not the same: the intake of the women on average was very low. Yet they were living in perhaps the most fertile region on Melanesia and food was moderately plentiful . . . again, the absence of an increase in food intake during pregnancy seems paradoxical. The comparatively small rise in energy intakes among the lactating women whose babies were more than one year old are almost as inexplicable.' These are a people whose activities resembled more those of Lawton's 'food-gatherers', though they combine cultivating 'gardens' with collecting food such as breadfruit and Galip nuts. There were, however, some seasonal variations in food intake though these appear to have been far less marked than among Genieri villagers for whom pressure of population on resources in land left little scope for food-gathering in the absence of open jungle.

Rowland *et al.* (members of a multi-disciplinary team from the Dunn Nutrition Unit in Cambridge[9] who carried out an in-depth longitudinal survey in Keneba, a small isolated village situated in the West Kiang Peninsula in The Gambia and having similar characteristics to Genieri village), have also observed that pregnant and lactating women 'have intakes considerably below the normally expected range'. They continue, however, to say that many of the adverse factors operate mainly during one period of the year, the rainy season. 'A mother who produces her child at this time will have suffered more weight loss herself during pregnancy producing a smaller child who then gets less breast milk.' The ill effects upon the infant are compounded by food contamination and poor food handling when mothers are under pressure of farm work. 'These same seasonal dependent work commitments', they state, 'contribute to the highly unfavourable energy balance seen in the rainy season in pregnant and lactating mothers.'

Part of the unfavourable energy balance is attributable to crop losses before the harvest is even begun (Table 2.4). The low ratios of energy gain over energy expended for Genieri village (Table 2.1) in respect of the two major foodgrains, late millet and rice, are partly explained by this factor. Jagne[10] reports that the major insect pest of standing ripening crops of millets and sorghums in The Gambia is the angoumois grain moth *Sitotrogga cerealellea*, and he states that this pest is liable to persist in store; but there are others which also infest the standing crop, apart from bird damage to which reference has already been made. Paddy, on the other hand, he claims is the most insect pest-resistant of all the food grains grown in The Gambia, although he still finds *Sitotrogga cerealellea* to be the main problem of the standing crop. The unfavourable energy balance is further affected by losses in store during

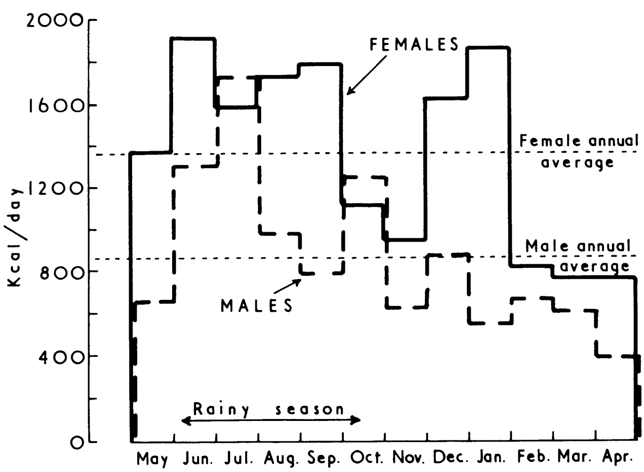

FIGURE 2.1 Seasonal pattern of energy expenditure on agricultural and other essential tasks: adult farmers, Genieri village

TABLE 2.4 Annual average 'energy balance', Genieri village, 1949/50

	Adult male farmers (16 years and over) kcal/head/day	Per cent
Energy requirements for adults aged 20–39 years[a]	2647	
Negative energy balance[b]		
108 farming days	3013	−13.8
Positive energy balance[b]		
257 non-farming days	2543	+3.9

Energy expenditure distributed over the 24 hours[c]

	Agricultural work(%)	*Non-farm work days(%)*
Agricultural work	46.0	–
Routine	8.9	20.9
Leisure	28.2	59.0
Sleep	16.9	20.1

	Adult female farmers (16 years and over) kcal/head/day	Per cent
Energy requirements for adults aged 20–39 years[a]	2320	
Negative energy balance[b]		
164 farming days	2693	−16.1
Positive energy balance[b]		
201 non-farming days	2082	+10.3

Energy expenditure distributed over the 24 hours[c]

	Agricultural work(%)	*Non-farm work days(%)*
Agricultural work	48.0	–
Routine	26.9	39.5
Leisure	9.0	39.7
Sleep	16.1	20.8

[a]See Appendix I.
[b]Compare Table 1.7 for seasonal pattern and Table 2.3 for labour utilisation in subsistence farming.
[c]See Appendices II and III.

the long dry season of the vital cereal crops all of which are grown for human consumption. Store structures, Jagne emphasises, 'are very poor. They are neither insect proof nor rodent proof. They are mainly for short-term storage, i.e. from one harvest to the next when they are completely cleared.'

3 The Emergence of Distinct Patterns of Energy Resource Utilisation

Regardless of however careful measurements of human energy and nutrient intake in subsistence economies are made, it is clear that there remain many imponderables. Men and women in tropical regions inexplicably appear to subsist at levels of energy intakes often well below the supposed FAO/WHO requirements of even their lowest category, that for sedentary workers, i.e. 42 and 36 kcal/kg of body weight respectively.[1] Norgan *et al.* enquiring into the effect of body mass on intake[2] show that 'the highest mean value for the Kaul men – that for the young men – was 155 kJ (37 kcal)/kg'; while no group among the Kaul women came even near the lowest FAO/WHO value, i.e. 150 kJ (36 kcal)/kg. On the other hand, Lufa men just about equalled the FAO/WHO value for 'moderately active' men of 190 kJ (46 kcal)/kg; while Lufa women were almost all within the 'moderately active' category of 170 kJ (40 kcal)/kg, and some even in the 'very active' FAO/WHO category of 200 kJ (47 kcal)/kg. There were similar disparities in Genieri village in 1948/9 where the lowest values for women as with those in Kaul appear to have come nowhere near even the lowest FAO/WHO value, while Genieri men seem to have just about equalled the FAO/WHO value for the 'moderately active', and in exceptional cases actually equalled the

FAO/WHO value for 'very active' men during periods of peak consumption, though these intakes do not coincide with peak activity.[3]

'Many of the calculations of energy *requirements*, and much of the basic assumption in relation to factors of improvements in energy balance, rely upon the probability that body mass plays a significant role in energy expenditure,' states Norgan and his co-workers in citing the case of the New Guinean populations whose circumstances

> would appear to have been almost ideal for demonstrating the dependence of energy intake on body mass. There were no complicating social factors – everyone lived in the same type of dwelling, ate the same foods, and led the same sort of life. Everyone was moderately active physically and everyone was lean. Yet even in this homogeneous group the correlations between energy intake and body mass are low. This is an unexpected and upsetting finding and must cast some doubt on the validity of using body mass as a highly important factor in calculating energy requirements.

How homogeneous is any such group in its energy *output* is open to question. Culwick, working among the Zande of the south-western Sudan,[4] showed the community eating in excess of requirements in certain seasons and apparently receiving an inadequate supply of calories in other seasons, and she emphasised that the overall pattern hid a great deal of individual variation and that individual circumstances readily over-rode the general seasonal trend. Signs of stress were reflected in not bothering, or not being able, to prepare and cook proper meals, and the general impression was one of a precariously maintained balance between a state of relative well-being and states of stress, complex in both origin and manifestation. Does this imply that the low productivity activity associated with farming for subsistence is a result of inertia or are farmers' choices genuinely conditioned by their evaluation of leisure? It is too simplistic to argue that the amount of labour available for farm work is solely dependent on the number of members in the family who can work on the farm and the length of time each is prepared to do so.

Labour and Social Control

Similarly, everyone in Genieri, a West African Mandinka village, lived in the same type of dwelling, ate the same foods, and led the same sort of life. Gamble[5] describes the Mandinka villages as being 'large, compact settlements of from two or three hundred to several thousand people, generally situated from one to five miles (8 km) apart. The village can be considered the highest effective unit of social organisation.' Within this structure the extended family system prevailed among households in the early post-Second World War period and authority rested in the hands of lineage heads whose social status within the community had a decided bearing on their ability to command resources in labour.

The people of the area fed and housed themselves by their own efforts and spun and wove cloth for 'everyday' wear. Their simple windowless dwellings built of bamboo, mud and thatch upon the bare earth were poor protection against the vagaries of the climate: but although the quantitative evidence showed a close approximation to equality of consumption necessary for survival, the notion that this was because more fortunate kinsmen customarily shared food with the less fortunate must be called into question. To a certain extent households did ensure their food supply by establishing the right to reciprocal services when needed. Even so, hierarchical institutions existed from earliest times when men fought for possession of strips of land; the strongest and the most skilled in hunting and battle attained the prize and to their numbers added minions caught in the 'crossfire', thereby bringing an element of servile dependence of one sector upon another into the social structure. As settlements grew 'strangers' arrived and took up residence, sometimes bringing skills, sometimes claiming ties of kinship, sometimes bringing goods for barter.

This was a society, however, in which group controls were exercised through lineage heads of compounds and the opportunity to accumulate capital by individuals within households was virtually non-existent. The main way by which additional labour was supplied at peak periods of demand was through the *Kafo* system – groups of men and women, boys and girls organised into age–sex teams falling roughly within five years of one another among the younger members and ten years among older people. Freeborn descendants of founder-settlers had priority in calling upon the *Kafos*; but the *Kafo* organisation was costly for the farmer in millet, goat meat and other foodstuffs and wherever possible farmers resorted to the alternative of calling upon neighbouring households with ties of kinship to give reciprocal services; here again freeborn descendants had the greatest call upon this kind of help when pressed for labour, whereas peoples of slave origin who were often short of labour had not the same call upon joint working parties giving reciprocal services.

Study of the social structure of Genieri village in the immediate post-Second World War period revealed that social status favoured those who could claim to be direct descendants of the original settlers and founders of the community. Settlers coming in later, although they may have been living in Genieri for many years, were still regarded as 'strangers', while families of slave origin were looked upon as of inferior social status. The village was divided into three main wards (kabilo). Gamble describes the functions of wards as follows

> The nucleus of a ward is a patrilineal kin group, but the ward includes the wives who marry in, the descendants of settlers, people of slave origin, and the 'low caste group', which includes the smiths, leather workers, and musicians and singers. A woman is normally regarded as becoming a member of her husband's ward, and should her husband die, she almost invariably marries a brother or parallel cousin of the deceased, and continues to live in the same ward.[6]

The aggregate of huts which made up the family compound or household, and which traditionally include one or two married brothers or married sons of the compound head, was separated from its neighbours by a fence of bamboo lashed to stakes of a termite-resistant wood. The Genieri village compounds were identified by the Field Working Party survey team by the letters of the alphabet, the largest compound in 1949 being 'O', which contained 76 men, women and children. Figures 3.1 and 3.2 outline the social stratification and subsequent changes for ease of reference.

Analyis of human resourse use indicates that measurement of intensity of energy expenditure and its relationship to the structure of the labour force within individual households is a more realistic approach to the study of the wide variations which were actually observed giving rise to states of stress and relative well-being, than attempts to correlate body mass with energy requirements. These findings have been further substantiated by the 1962 and 1973 re-surveys: Table 3.1 compares four households – O and K of freeborn descendants, R of slave origin, and B of immigrant settlers (for which a detailed record was also obtained in 1973) – and illustrates the close correspondence between their

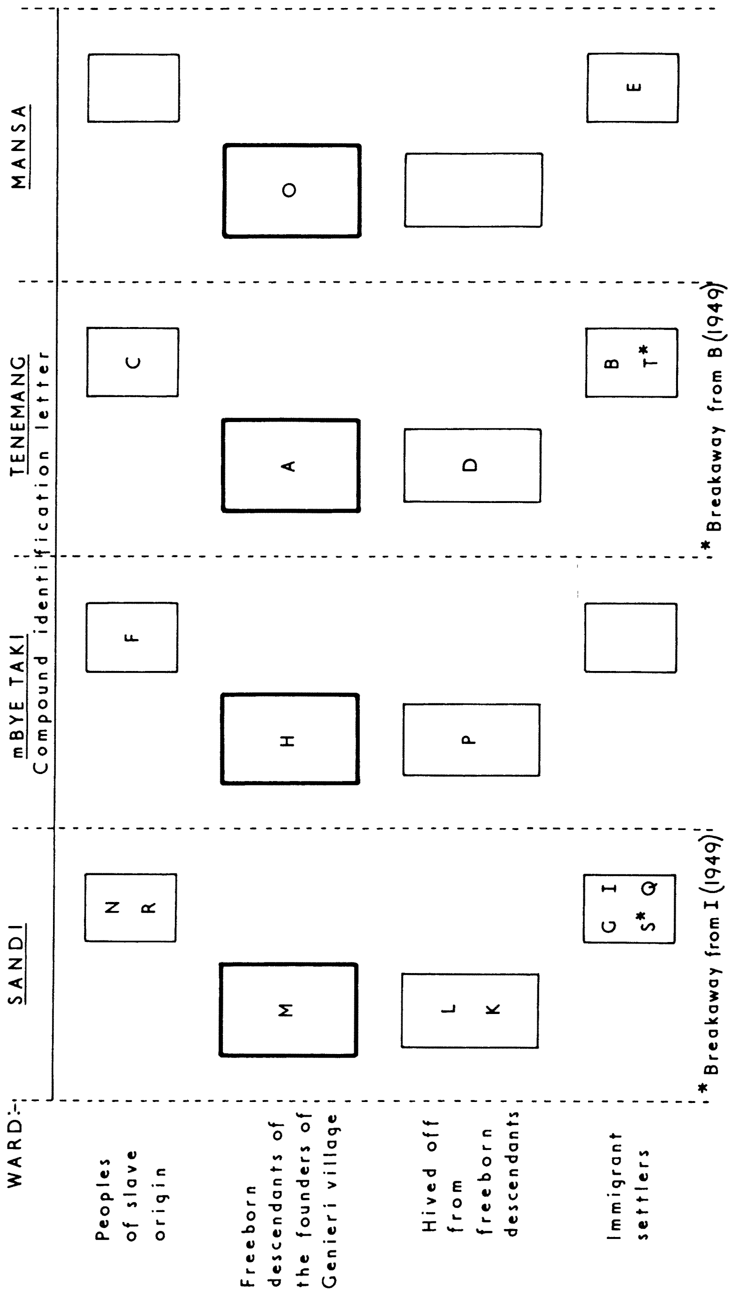

FIGURE 3.1 Outline of social stratification: Genieri village, 1949

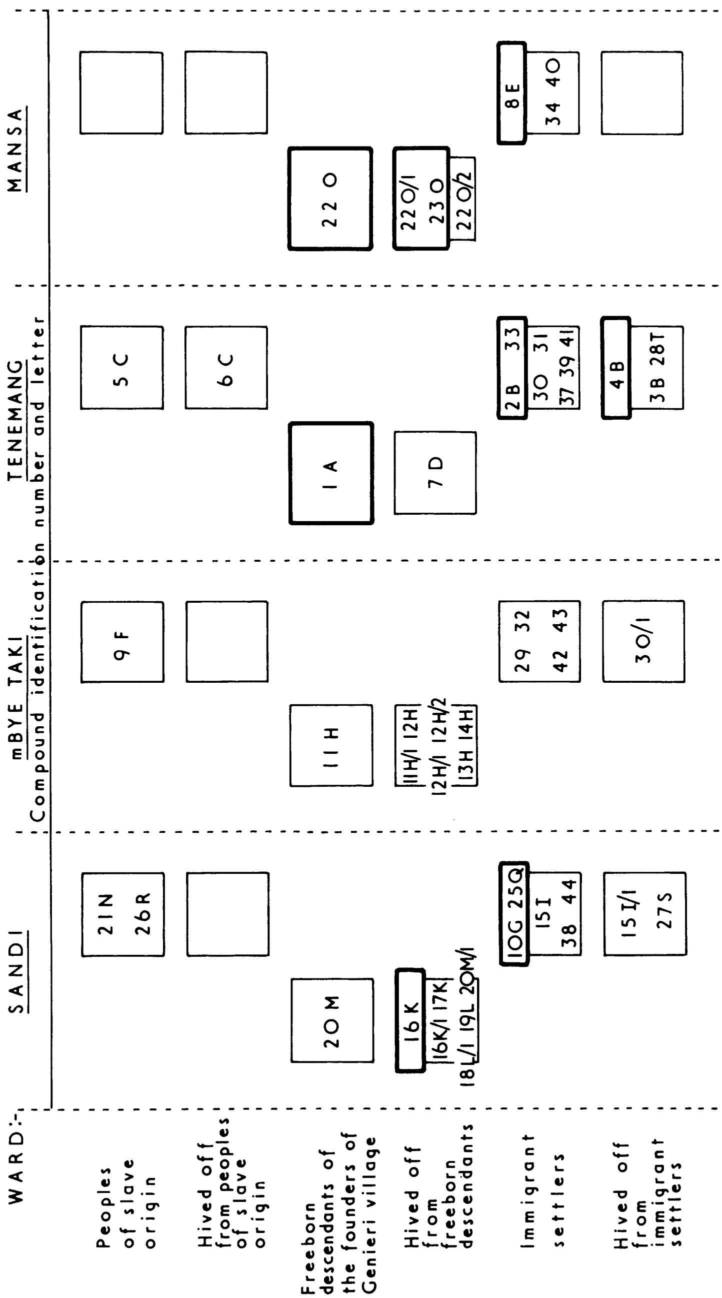

FIGURE 3.2 Outline of social stratification: Genieri village, 1973

TABLE 3.1 Mean energy expenditure at work in agriculture (including walking and resting element) in some Genieri households compared with the village average households, 1949/50 season

	All village	*Compound household code* O	*K*	*R*	*B*
No. of farmers					
Male	158	29	9	4	14
Female	165	21	12	4	23
		kcal per minute			
Age group					
Males					
Under 11	2.72	2.76	–	–	2.80
11–15	2.95	2.80	3.15	–	3.02
16 and over	3.98	4.01	4.08	3.60	3.91
Females					
11–15	2.39	–	2.42	–	2.43
16 and over	3.19	3.23	3.21	3.21	3.16

activity rates in hand-hoe agriculture with those of all the village households taken together.

Since variations were minimal in both cropping patterns and agricultural operations between one household and another energy supply within the households becomes the critical factor which calls for examination of the structure of the labour force. Table 3.2 indicates the order of magnitude of changes in the labour supply within each compound over a period of time: the number of male and female farmers in the three age groups (under 11, 11–15, and over 16 years) in 1949 and 1973 has been multiplied by the mean energy expenditure for an hour's work (including the walking and resting element) presented in Table 3.1 to estimate the aggregate energy available for the household's subsistence production, divided by the total population of the household. For comparability these calculations have been converted to index numbers.

TABLE 3.2 Human energy supply index*

Compound identification letter	*1949*	*1973*	
		Compound intact	*Breakaway households*
Freeborn descendants of founder-settlers			
A	114	110	
D	128	96	
H	79		
11H			75
11H/1			92
12H			86
12H/1			49
12H/2			90
13H			125
14H			71
K	94		
16K			102
16K/1			138
17K			106
L	116		
18L/1			95
19L			118
M	102		
20M			124
20M/1			82
O	99		
22O			104
22O/1			97
22O/2			71
23O			87
P	102	Abandoned: no trace left	
Peoples of slave origin			
C	110		
5C			115
6C			86
F	90	101	
N	114	74	
R	115	115	

TABLE 3.2 (*continued*)

Compound identification letter		*1949*	*1973* Compound intact	*1973* Breakaway households
Immigrant settlers				
B		97		
	2B			72
	3B			87
	4B			81
E		120	109	
G		107	116	
I		104		
	15I			Mentally sick living alone
	15I/1			91
Q		90	82	
S		109	115	
T		115	118	

*All village 1949 = 100 = 136 kcal/hour per capita.

The findings of the 1947–50 surveys of the Human Nutrition Field Working Party showed that total harvests reaped were adequate to meet the needs of the village. This leads to inquiry into the variations in energy availability between households to establish where surpluses or deficits actually occurred. Based on the author's detailed and exhaustive measurements of household populations and occupational activities in hand-hoe agriculture, Table 3.3 has been constructed to provide a 'rule of thumb' indicator which can be adopted for any subsistence agriculture society dependent on human energy where the total household population and the structure of its farm labour force (sub-divided by age and sex into those under 11, 11–15, and over 16 years) is known, simply by applying the mean energy expenditure at work in agriculture rates given in Table 3.1 (see also pp. 63–5). This obviates the need to repeat the arduous

TABLE 3.3 Human energy required for hand-hoe agricultural production to supply the consumption needs of the household for subsistence

	kcal/hour per capita of total household population	*Index No. cross-reference (Table 3.2)*
'Safe level' for the support of a traditional hand-hoe agriculture	136	100
Range within which a traditional hand-hoe agriculture can normally provide for subsistence	137–69	101–24
Point below which a traditional hand-hoe agriculture cannot provide for full subsistence	101	74

and costly task which, almost without exception, fails to be carried out in pre-investment studies, with the result that important issues relating to human resource endowments are often overlooked because no household-by-household comparison is available to suggest specific lines of inquiry. A mid-year population census was taken by age and sex and by household for the entire village of Genieri in 1949 and 1973 by the author, and it has therefore been possible to apply this method (Table 3.2) both to illustrate its validity as a time-saving device for estimating the viability of subsistence economies in early stages of agricultural development, and to indicate changes in fortune of particular households.

From Table 3.2 it can immediately be seen that although the point below which a traditional hand-hoe agriculture cannot be sustained had not been reached by any household in 1949, compound H was fast moving into this position and the process of hiving-off to form smaller compounds of nuclear family households began shortly after. By 1973 the 71 strong family unit of extended family members had been resettled into 7 new households, averaging 12 men, women and children. The break-up of the extended family into nuclear family households did not arrest their dilemma however. Compounds 11H/1, 12H/1, 12H/2 and 14H were poverty-stricken households in 1973 still living in traditional mud and thatch huts and only 12H had accumulated wealth in cattle and improved housing. By 1979 14H had been abandoned and 12H/1 whose compound head was, exceptionally, a woman, re-absorbed. The hiving-off process by compound O which contained 76 men, women and children in 1949, started from a healthier vantage point and met with greater success. The average number of men, women and children in their newly-formed households was 21 in 1973 and this allowed for a better structured labour force – excepting for the destitute compound 22O/2 which had only 7 occupants and was dependent upon the energies of the very aged and adolescents.

Changes in Available Sources of Energy

DeBoer and Welsch point out that 'with respect to inputs and products, the subsistence farmer, by definition, buys few agricultural inputs and consumes most of his output. He is almost totally self-sufficient. At the other extreme, the highly commercialized farmer buys nearly one hundred per cent of his inputs and sells nearly one hundred per cent of his production.' Following a detailed field study of cattle and buffalo production in a north-eastern Thai village during 1970–1, DeBoer and Welsch found that the farmers had been pretty much at the subsistence end of the spectrum a generation earlier, but that during the intervening period they had moved a considerable distance toward the commercial end of the scale in disposal of the output though not so far in regard to inputs. 'Rice, the main activity, still is operated as a subsistence activity.' They argue that changes in crop and livestock technology have come about from three major sources: the proximity of the village to a surfaced highway, for although labour and land costs increased, transportation and communications became very much less costly; access to a livestock breeding centre; and, since the late 1950s, participation of the village in the rapid expansion of upland crops in the region. The result of these developments, DeBoer and Welsch state, has been increased cash incomes and a sustained demand for draught animal power.[7]

Although the cultivation of upland soils with draught oxen had been practised for many years in the Upper River Division of The Gambia, this form of energy was not used in the Lower River Division in which Genieri village is located before the late fifties and then through the initiative of The Gambia Department of Agriculture.

The author's first re-survey of Genieri in 1962, however, found the village still wholly dependent on hand-hoe agriculture. Where household income allowed for surpluses above the minimum for subsistence these were utilised on the products and services of village craftsmen, medicine men and traders: items such as clothing and building materials (especially corrugated iron sheets to replace grass thatch) were purchased. The purchase of draught oxen by the more affluent households came later. The transfer of some of the energy required for agricultural production to animal power permitted some members of these households to utilise their energies instead in other productive occupations. It was not that farming became a part-time occupation but that not all the resources of human energy available in the household were now needed to ensure its subsistence.

Draught oxen were used for the more arduous task of land preparation on upland soils and Table 3.4 indicates the considerable fall in human energy for agricultural production where households substituted animal power for some tasks normally carried out by men and boys. The harnessing of the energies of animals for agricultural

TABLE 3.4 Human plus animal energy supply in households owning draught oxen, Genieri village, 1973/4

Compound identification letter	*kcal/hour per capita of total household population*			*Index No. cross-reference Table 3.2 (100 = 136 kcal/hour per capita) combined human and animal*
	Human	*Draught oxen*	*Total*	
Freeborn descendants of founder-settlers				
22O	142	42	184	135
22O/1	132	100	232	171
23O	118	53	171	126
Immigrant settlers				
2B	98	30	128	94
Q	111	72	183	135
1979 updating[8]				
2B	138	27	165	121
23O	108	119	227	167
16K/1	181	–	–	133
26R	117	–	–	86

production released three men in compound 22O for non-farm full-time work in carpentry, masonry and fishing, one man in 22O/1 as a tailor, and one man in 23O for petty trading; compound 2B also had a full-time tailor as well as an Arabic teacher, and in compound Q one of the men engaged in petty trading and another became a shipwright.

The energy resources of the 1973 sample compounds 2B, 16K/1, 23O and 26R were updated in 1979, and the findings indicate that households owning draught oxen in 1973 have been able to strengthen further their energy resource base for agricultural production. However, for the regular feeding of oxen at work some foodgrains, access to crop residues, and forage resources are essential. For the less fortunate, the two households 16K/1 and 26R, a worsening situation is fast occurring. At both ends of the spectrum households relying on their own resources for their energy supply, i.e. those households operating around a high of 169 or a low of 101 kcal/hour per capita (Table 3.3), had a family labour force the structure of which was distorted by dependence on those over 39 years and under 20 years of age and small household populations. While households of very large numbers of extended family members in earlier times provided subsistence security, their break-up into nuclear family units encouraged by culture contacts and improved physical access has not enabled hand-hoe cultivators to break out of the energy restrictions wherever re-settlement has been carried to the point of extremely small households running into single figures.

Food and Labour Implications for Farm Family Households

Table 3.5 shows the dependence upon the energies of the 20–39-year age groups in Genieri village for the subsistence of all its residents in the early post-Second World War period when the region had no access to alternative sources of energy; and we may first inquire into the changed circumstances over time of those households which have not been able to use the energy supply of animals to do some of the work in the production of food. Even as early as 1949 compound R was a small household of only 11 occupants; at that time the then 40-year-old compound head had family labour available to provide an average of 157 kcal/hour per capita of the total population of the household – significantly above the 'safe level' for their subsistence (Table 3.3). However, though the source of family energy supply was from among the 20–39-year-old age group, helped by

TABLE 3.5 The 'closed economy' of Genieri village, 1949/50: aggregate hours worked in hand-hoe agriculture by age and sex

	Total hours ('000)	*Per cent*
Males		
Under 11	6.3	6.7
11–15	14.3	15.2
16–20	14.2	15.1
21–30	17.6	18.8
31–40	20.7	22.0
41–50	6.8	7.2
51–60	1.5	1.6
61–70	0.4	0.4
All family labour	81.8	87.0
Reciprocal labour:		
Kafo	4.5	4.8
Group work based on kinship	5.1	5.4
Unclassified help	2.6	2.8
Total	94.0	100.0
Females		
Under 11	–	–
11–15	14.3	8.1
16–20	15.1	8.5
21–30	79.3	44.8
31–40	33.9	19.2
41–50	15.2	8.5
51–60	6.8	3.9
61–70	1.6	0.9
All family labour	166.2	93.9
Reciprocal labour:		
Kafo	6.9	3.9
Group work based on kinship	0.2	0.1
Unclassified help	3.7	2.1
Total	177.0	100.0

younger boys and girls, the compound head had to draw extensively upon the help of other villagers to ensure their subsistence: only 46 per cent of the labour *time* was contributed by family members in 1949. By 1979 this same compound head at 70 years of age still relying upon the human energies of a small household but of now ageing men and women and lacking the contribution of adolescents was destitute with severe problems of food deficit. No less serious was the situation of all other compound households of less than 10 occupants in 1973 (when a population census was taken of the men, women and children in every household of the village): the supply of food in store from the previous harvest was exhausted many weeks before the new harvest was reaped and these particular families suffered from severe shortages resulting in dangerously low consumption levels especially among vulnerable groups – infants, and pregnant and lactating women.

Whether or not the energy gain over energy expenditure in the production of crops for subsistence by means of a hand-hoe agriculture[9] is relatively high, continued dependence on such a system for subsistence is both unsupportable in the long run and forms no basis for energy substitutes in the short run wherever household population is composed of older members and the very young and energy availability limited by the small number of occupants. Culture contacts are nowadays widespread and reliance can no longer be placed on the help of others within village structures whose overall population is itself distorted by migration of some of the physically fitter members of the society, notably in the younger age groups (Fig. 3.3).

The arrival of immigrants from other rural areas over the period 1949–73 nonetheless suggests the emergence of a thriving society in Genieri; what were the attractions? In some cases immigrant families brought with them a skill; others were attracted by the construction of a

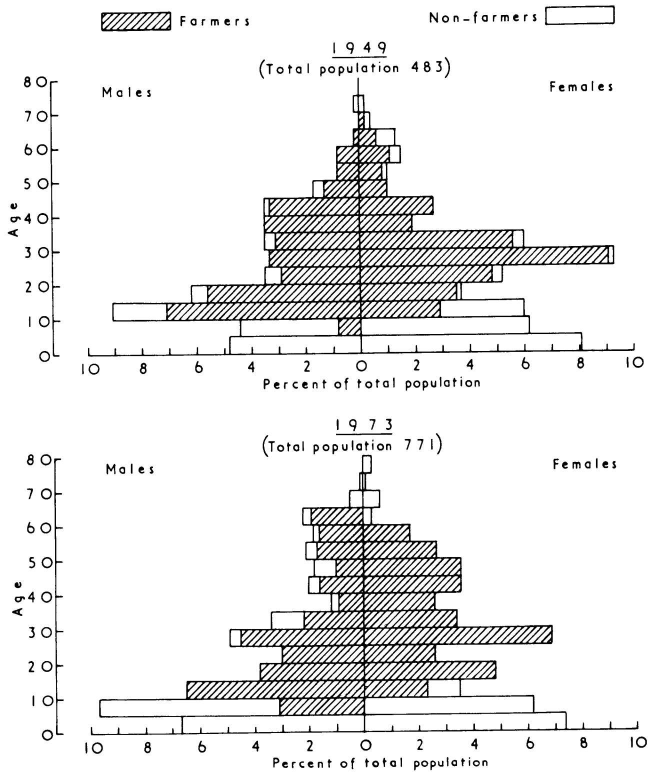

FIGURE 3.3 The change in the demographic structure of Genieri village

surfaced road, built in the late sixties, which passed close to Genieri village and promised the opening up of trade routes. While the growth rate over the period 1949–73 for immigrant settler inhabitants resident in 1949 was low – 1 per cent per year – for all immigrant settlers a growth rate of 4.4 per cent was recorded in a situation where the rate of growth of total population was only 1.9 per cent per year. Yet by 1979 many of the new immigrants had abandoned their homesteads and moved elsewhere, on the one hand in response to the declining fortunes of the indigenous population with the proliferation of numerous small households of ageing family members living precariously on the breadline and unable to purchase their skills, and on the other hand as resources in land became increasingly scarce.

If Jay Saidy interprets the events over the past 30 years between 1949 and 1979 as a time of stagnation when this Eastern Kiang village missed the chance it had for a social, cultural and economic breakthrough, then he has entirely misread the signs.[10] It is questionable whether development economists, agronomists and administrators have ever fully understood the factors which bedevil so many external attempts to modernise the agricultural sector of low-income rural areas of the tropical and sub-tropical world; the political overtones, the activities of powerful men in traditional village societies, the role of women, the conflicts and animosities. When Miriam Sharma[11] writes about politics and inequality in India, she declares these to be universal aspects of human society: it is only the form of political activity and the way in which inequality is manifested in behaviour which differs. As in the case of her own detailed study of a particular activity system, the few men of Genieri who have had both the desire and means to compete actively in the village continue to control whatever resources enter the village, make decisions regarding their distribution, and are at the centre of the village's political activity. The dynamics of change in Genieri is closely linked with *their* activity in expanding their own resources and power over time and advancing their own families' position.

'A particular family may rise or fall on the wealth and prestige scale as the years go by,' writes Sharma, 'but this is a slow process rather than a sudden change; but the big men of to-day still come from other families that were highly regarded in the past. While a change has taken place in the type of leadership at the village level, there is a certain amount of continuity between the leading families of the past and the present-day big men.'[12] No less can this be said of Genieri in which, by virtue of their status in the society, the wealth of particular families in 1949 resided in their overwhelming resources in human energy applied to favourable resources in land. Nowadays, substituting animal power for the more energy-demanding tasks has obviated the need to maintain a large pool of human labour to ensure their subsistence and has ironed out some of the seasonal peaks; the surplus capacity has been channelled into non-farm productive activity.

The possession of draught oxen has been but one aspect of cattle ownership however. Households owning draught oxen (Table 3.4) also owned 38 per cent of all the village cattle in 1973–4, while a further 13 per cent were owned by the village headman (compound A), and 12 per cent by the village money-lender (new immigrant settler compound 33):[13] wealth in cattle was concentrated in the hands of the privileged few – a feature which was absent in the 'closed economy' of the 1940s. If it was the intention of government extension agents in the late 1950s that animal husbandry should become an integral part of the farming system through the introduction of livestock enterprises by emulating a Western-type farm family structure, then they have signally failed. Cattle management consists of little else but herding; milk yields are pitiful; and the possession of cattle is mainly for prestige and a readily convertible form of capital investment. Forage resources, crop residues and feedgrains consumed by the 1973–4 cattle population of 188 head are estimated in Table 3.6 which indicates that these were not sufficient for their maintenance and that severe seasonal weight losses occurred.

DeBoer and Welsch conclude from the findings of their study of cattle and buffalo production in a north-eastern Thai village that 'it is difficult to alter one part of the interrelated crop–bovine production system without changing other parts. . . . Changes in only one area are not

TABLE 3.6 Potential cattle stocking capacity, Genieri village lands, 1973/4

	Dry season (120 days Feb.—May) *Millet residues*	*Groundnut residues*[b]	*Wet season*[a] *(245 days June—Jan) Grazing*
Area (ha)	50	150	224[d]
Yield of DM (kg/ha)	850	300	800
Supply of DM (kg)	42500	45000	179000
Requirement/ animal per season (at 4 kg DM/ head per day)[c]	480	480	980
No. of animals which can be supported	$\underbrace{89 \quad 94}_{183}$		183

[a]The rains finish by the end of October but cattle grazing continues into January.

[b]There is now a market in groundnut haulms, indicating acute seasonal shortage of livestock feed. In May 1979 these were selling at about 4 butuks per kg (1 Dalasi = 100 butuks).

[c]Draught animals require a ration of 3 kg millet grain on days when working (equivalent to about 0.5 kg/head per day spread over a year, or a total of 182 kg). The foodgrain requirement of each draught animal is therefore equivalent to the subsistence requirement of one adult person; draught oxen were used in pairs for ploughing. In practice grain was rarely spared for livestock feed.

[d]This is the grazing area necessary in the wet season to support the 183 animals which can be maintained in the dry season. The potential grazing area in Genieri was slightly in excess of this figure, but it has to be remembered that most of the year the pasture is nitrogen deficient and therefore protein deficient, and also phosphorus deficient, resulting in low conception rates and certainly low calving percentage. The role of legumes in pasture improvement (e.g. *Stylosanthes* species is to provide a protein supplement. A side effect of this is to increase intake by the animals of low nitrogen fodder, e.g. straw, mature natural grass. Without such a protein supplement intake of these materials will be low.

Source: Table based on data collected by the author over the period 1947–79.

likely to be enough. For example, farmers were prevented from taking full advantage of the performance potential of the Brahman crossbreeds because inadequate nutrition was being provided by the crop production system.' Climatically, conditions in the north-east of Thailand are similar to those in The Gambia in which a short wet season is followed by a long dry season. In both areas, as soon as the crops are planted all cattle are herded individually or in very small groups (with village children doing most of this) to avoid straying on to cultivated plots and causing crop damage; but as soon as the harvest is over herds are combined and allowed to graze on crop residues on the harvested fields. This is the period at the end of the rains (November to January) when temperatures are moderate and although the rains have stopped the extremely dry conditions have not yet begun. Rufener in a related study in villages of north-east Thailand found that mature animals lost 10–15 per cent of their body weight during the period January to April, a finding which corresponds closely to that of cattle owners in The Gambia.[14] 'If one assumes that the total village area was available during December–March,' state DeBoer and Welsch, 'carrying capacity would amount to 5.6 hectares per animal; but carrying capacity drops rapidly as the rains start and crops are planted, reaching a low of about 0.32 hectare per mature animal equivalent. As less land became available, animal owners spent up to 200 person-hours per month cutting grass and weeds in the crop areas and hand carrying them to their animals.' DeBoer and Welsch further reported that 'high levels of herding labor continued even after harvest when communal grazing was available'.[15]

One important difference between the Gambian cultivators and this north-eastern Thai community is that although the main activity of every household in both communities is to grow rice as a subsistence crop in order to make secure the family food supply, according to

DeBoer and Welsch, north-eastern Thai customs prohibit rice threshing (done by hand) by women. The numerical strength of the female labour force in individual households in Genieri village where rice continues to be cultivated, harvested, stored and threshed by women, is a critical factor for those households still dependent on the human energy supply of a hand-hoe agricultural production system. Threshing involves hand-pounding using pestle and mortar and this with drawing water constitutes the most energy-demanding of year-round domestic tasks (Appendix III). Family households in 1973 which were both small and wholly dependent on the hand-hoe agriculture of women and girls were operating at a level which was too low for their subsistence (i.e. with a mean energy supply availability of only 95 kcal/hour per capita of total household population), and all were in very serious difficulties, approaching famine conditions, at the beginning of the 1973 agricultural season. Table 2.4 and Figure 2.1 are reminders of the extremely unfavourable energy balance of adult female farmers occasioned by the seasonally-dependent work commitments of agriculture, and with no relaxation from essential routine tasks.

However, the record of individual body weights of all males and females in Genieri village in July 1973[16] gives no indication of stresses and strains of particular households during this season of acute food shortage. The average body weight of the 20–39-year-old population was

males 57.83 kg
females 52.06 kg.

These figures are not significantly different from those of the 20–39-year-old male and female population in January 1962 (the season of post-harvest relative food abundance), including as they do the body weights of those in a better position to balance food intake with requirement, the 'newly affluent' members of the society who have been able to transfer some of the power needed for agriculture to animals and who as a result of the lower human energy requirements are able to follow other productive occupations.

4 Key Issues in Energy Resource Allocation

One of the reasons cited by Durnin and Passmore[1] why practical interest has grown in the subject of the rates at which the human body utilises energy is that in most countries the population is increasing rapidly and more food is needed. But how much?, they ask, and suggest in answer that this depends on the type of life future generations choose to lead, and on the extent to which new sources of power remove the necessity for manual work. Their writings are however from the perspective of the prosperous industrialised societies where 'man's eating times are determined by habit and custom. He is seldom really hungry. His breakfast, his midday and his evening meals, are ready for him usually at a fixed time and he eats them because the meals are prepared'.

Bunting speaks for agriculture:

> the farmer in Oxfordshire or Ohio is a business man who devotes virtually all his resources of land and other environmental factors, labour and other sources of power, capital, knowledge, time and attention to his farm business. His wife shops at the supermarket; he buys his clothes from a shop; his farm equipment and materials, and his produce, pass through accepted commercial channels; water, electricity, and gas come from the mains; and his working capital comes from the bank. On the other hand, the traditional rural community in Orissa (India) or Tanzania (Africa) has to do virtually everything for itself. It has to allocate its

> very limited resources among a wide range of competing activities of which agricultural production is only one. It may be short of land, water, cash and especially of power, particularly at peak periods of the year; moreover, its decisions about the allocation of these resources will be far more heavily tilted towards survival and security than those of the farmer in a richer country.[2]

On the one hand, new sources of power which remove the necessity for manual work are 'pies in the sky' for the world's rural masses in the less-developed countries of the tropics; on the other, the metamorphosis which these same traditional societies are actually experiencing is the outcome of creative forces at work which are derived from the energy output and the timing of energy utilisation of particular members, of particular families, in particular circumstances of status and prestige. To treat these societies as homogeneous groups because everyone lives in the same type of dwelling, eats the same foods, and leads the same sort of life, is to confirm the ill-founded basis upon which our tediously repeated generalisations are rushed into print. Yet to undertake the laborious and expensive measurement of energy expenditure on all the separate activities throughout the day of each individual is a marathon task which few researchers have accomplished at any time.

A Formula for Assessing the Human Energy Supply of Family Farmers in Subsistence Economies of Low-income Tropical Regions

Inquiries into whether or not men and women are applying their energies to soils of low fertility, to patterns of crop production which keep them subsistence-tied, to technologies which are primitive, and so on, are of little avail if the human energy supply which supports these systems is not known: without knowledge of the human resource endowment, other production data provide an insufficient basis upon which to formulate guidelines for policies and programmes that will result in accelerated growth of agricultural output. Furthermore, however well defined the basic needs of subsistence economies may be, it will be the existing resources in human energy and the existing social arrangements of the population for which they are intended which will decide their relevance: investment which enriches the *human* resources of these socities therefore becomes *the basic need*.

Since the arduous task of activity measurement has already been accomplished by the author, and with access to the recent work of the human biologists, it is now possible to offer a formula which provides a yardstick which future investigators can apply to any village population, regardless of the type of staple crop grown for its subsistence. The pattern of crop production is dictated by topography and rainfall; and societies depending on the human energy supply of family households for cultural operations have long adapted their work schedule to the prevailing environmental conditions, which is why attempts to change patterns of production by introducing new crops or strains have usually failed where the labour requirements of existing practices have not been measured. How can this data gap be overcome without recourse to costly and time-consuming measurements of energy expenditure on all the separate activities? The investigator must first take a count of the total population by household, by age and sex in the area of study, and then simply apply the 'mean energy at work in agriculture (including walking and resting element)' given in Table 3.1 to the members of the household engaged in farming to arrive at an aggregate figure of energy supply *and divide by the total household population*; an inventory of other sources of energy must also be taken to correct for 'below average' human energy availability where energy substitutes exist; the census should also note family members, if any, in non-agricultural occupations which are indicators of wealth. The resultant figure (expressed in this text in kcal/hour per capita) will indicate where weaknesses occur in the structure of the labour force and in human energy availability, how near the margin for subsistence are particular households, and which are those families best able and most likely to modify existing farm structures by introducing alternative sources of energy and extending human energy resources to other productive activities needed for rural development.

Between mid-November and mid-December 1979, six locally-recruited investigators under the direction of the author successfully applied this formula to 1558 household members in 15 widely-dispersed villages in the Central Province of Papua New Guinea. No special skills other than the ability to record and no prior training were required, and in the process of making these measurements much of value on behavioural patterns also came to light.

The Politics of Energy Substitutes for Food Security

There has been much pre-occupation over the last quarter-century with weaknesses in extension services in implementing rural development projects incorporating packages of technological inputs, and it has been too readily assumed that the percolation of new knowledge has failed to filter through to the lowest level: but the spread of information is far more efficient than is generally recognised. It is not the percolation idea that is the missing component, but failure to maintain the human capital in the process of technological change.

Given a favourably structured work force with high innovatory capacity among its younger members, what energy substitutes would they be seeking? Cancian observed among the Maya Indians in the highlands of Chiapas in southern Mexico, who work with hoes and the technique of slash-and-burn agriculture to produce the major part of their families' food, that for most farmers weeding is the biggest job of the agricultural cycle which sets a limit on the amount they can seed; and he noted that some farmers had begun to use chemical weed-killers.[3] Chemical sprays, however, constitute an important secondary energy cost in pesticide manufacture and transport, and Ruthenberg[4] in an analysis of labour input in typical African savannas shows that the emphasis changes from chemicals to reliance on animal-power and traction-power when a fallow vegetation of grass dominates and fields have been de-stumped. He points out, however, that the labour economy of ox-plough over hand-hoe methods of cultivation may be cancelled out by the greater work required for weeding. Here is an instance where pre-knowledge of whether or not there are reserves of human energy facilitates policy decisions: the great reduction of human labour input in groundnut cultivation in Senegal stems, according to Ruthenberg, from combining the ox-weeder with ox-ploughing.

It is important, however, not to confuse non-adoption of new technologies with weaknesses in the labour profile of traditional households. Figure 4.1 demonstrates the kind of problem which faces the farm family which is encouraged to increase its output of the staple foodgrain, rice, by the application of fertiliser – another secondary energy cost of considerable magnitude in its manufacture.[5] The energy value of rice yields net of fertiliser input have been calculated from data collected by the International Rice Research Institute (IRRI) in the Philippines.[6] The IRRI results on farmers' own fields indicate that it is only rational for farmers to fertilise in the dry season under controlled irrigation. As is well known, within irrigation farming human labour input tends to rise with increasing availability and reliability of water; but it is the

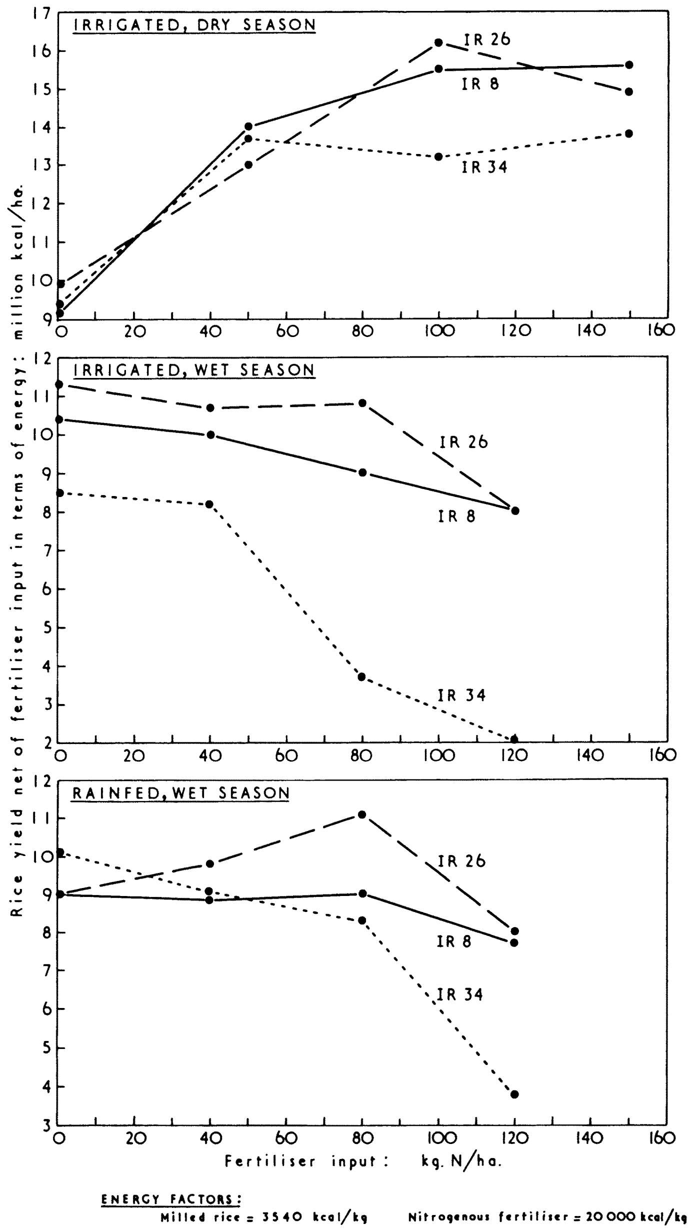

FIGURE 4.1 Energy value of rice yields net of fertiliser input, Laguna Province, Philippines, 1975 (farmers' fields)

disproportionate rise in labour input as multiple-cropping increases that precipitates the need to substitute chemical herbicides for human energy. To enable the purchase of these industrialised inputs, the human energy resources of farm family households will need to be greater than the supply actually required for subsistence production to release some members of the work force for non-farm income-earning activity to provide the working capital for the additional energy costs involved in their use on the farm. Once again knowledge of the human energy availability within farm family households is a pre-requisite for government administrators and other agencies faced with the problem of executing policies for agricultural and rural development. Villages with a preponderance of households heavily dependent on females and the aged are not the most obvious starting points for generating agricultural growth. Neither will they be located in regions which are likely to 'attract back to the land' young migrants in urban centres, even where the urban employment opportunities are few and living conditions at the margin for survival: electricity and piped water are now felt wants for those who have experienced these services which have yet to reach the rural areas of the subsistence economies which previously nurtured them.

The stagnation of subsistence economies today – small family units tied to traditional hand-hoe agriculture, depending on the human energy resources of a distorted population structure, cultivating soils depleted in nutrient content with increasing pressure of population or the adverse effects of destructive agricultural practices with their concomitant problems of soil erosion, lowered resistance to disease of the human population particularly in seasons of peak periods of labour demand (including arduous domestic tasks such as drawing water and pounding grain), exacerbated by conditions of poor hygiene, polluted sources and absolute shortage of water, and poor nutritional status – has been so much the pre-occupation of policy-makers that dynamic elements in all these societies which *can* be exploited for rural development have tended to be overlooked.

In Genieri in 1979 the nucleus of households which had been able to advance their own families' position were becoming 'politically active', refusing to pay their taxes because they claimed that essential supporting infra-structural services were not forthcoming. The 'big men' of today who owe much of their success to having been born into families which were highly regarded in the past, now form the pressure group which will effectively be the catalyst for change needed to revitalise the society; though in the process, structural change will necessarily occur which will force out of self-subsistence production households which can no longer maintain themselves excepting by incurring heavy burdens of debt for food: a shortage of food for family consumption will never call forth increased production, and since a large proportion of the urban worker's income is also spent on food, it is the marketable supply of *foodstuffs* which limits the effective demand for the products of the non-agricultural sector. Although borrowing facilities for cash outlays are an essential service for progressive households of family workers with the initiative and energy to take advantage of energy substitutes, it is their ability to enlarge their supply of savings in human energy over that required for 'essential consumption' that is the cornerstone of their development potential. As Bunting aptly puts it

> though the new procedures to be offered must be appropriate to the objective and resources of rural people, they do not necessarily have to be either intermediate or small. Tractors, at first small and then large, were the basis of the Japanese rural transformation 30 to 40 years ago. They are essential in the sparsely inhabited rainlands of Sudan as a future

breadbasket for the Arab world; and small tractors are so important in the rice-growing areas of south-east Asia that in Thailand, at least, internal combustion engines are manufactured in village workshops.'[7]

'The "more syndrome" – the concept that increases in productivity can only result from increases in inputs; more fertiliser, more insecticide, more energy etc. – has been impressed upon the farming of the tropical world for at least the past quarter century,' writes Ray Wijewardene. 'Doubtlesss,' he suggests,

> it gained momentum from the impressive successes of North American farming where environment as well as socio-economic conditions were ripe for its successful application. But only comparatively recently has its validity for the developing world been questioned in the face of continued marginal productivity, despite massive inputs, and 'expert' advice and funding! The possibility that pre-conceived impressions might have weighted the contention is now suspected – as also the impact of commercial endeavour on the part of those with agricultural inputs to sell who were faced with new, relatively untapped, markets to be exploited.[8]

The problems facing those farm family households in Genieri village who have introduced animal-drawn implements for some cultural operations exemplify the limitations of this system of energy substitutes for human energy which, because of shortage of grazing and the absence of surplus foodgrains (millet and sorghum) over human consumption needs for livestock feed, will have a decisive effect on the demand for tractor power as an alternative. Metrick draws attention to this problem in The Gambia: 'the opportunities therefore for expanding the national herd in order to provide draught oxen for those who have none are strictly limited. Any increase in the number of owners will have to come by redistribution rather than by expansion.'[9] This suggests that the introduction of ox-power as a substitute for human energy must be combined with a dramatic change in the traditional pattern of crop production to one of mixed farming (already tried with no apparent success by The Gambia Department of Agriculture). Mixed farming, as has been demonstrated, is typical of family farm structures in England, and is not only high cost and often wasteful of fossil fuel energy where large conventional tractors are used, but also very demanding in human energy for what, by Western industrial-country standards, constitutes no more than a subsistence livelihood (Table 1.3). As a viable system for the proper maintenance and health of animals currently precariously existing on very poor quality forage and crop residues with little or no supplementary feed however, it cannot be disputed and experimentation along these lines should continue. For example, a proposal was placed before the government of The Gambia in April 1979 for the establishment of a Pilot Farming Scheme consisting of a 14-acre holding (capable of supporting 4–11 adult workers) divided into four blocks of equal size, cropped and fallowed in rotation with forage – *Stilosanthes Guinansis (gracilis)* and *Brachia suziziensis* – with a yield potential of first-quality pastorage sufficient to maintain two oxen:[10] but the hidden costs are prodigous – training, technical advice, supporting veterinary services, cattle breeding centres and new management skills. The traditional subsistence farmer in tropical regions who has been able to substitute animal power for some cultural operations by exploiting a relative land abundance for communal grazing will not, as land resources become scarce, divert human energy resources to so complex and alien a system of intensive production. What alternatives are open to him?

Wijewardene makes the important observation:

> most farm tools have been developed for mitigating the TIME and ENERGY constraints to the physical production capabilities of the farmer. However, the former (time) constant has usually been exchanged for a higher input of an alternative energy – whether mechanical, animal or chemical, according to availability and cost. Generally however the product of TIME and ENERGY ($T \times E$) remains constant for any particular farm technology (as illustrated in Figure 4.2). Conventional manual farming (curve K_1) is fairly low in energy absorption but high in time. Conventional mechanised farming is low in time but high in energy consumed. (While manual energy input is reduced, mechanical – petroleum – energy input is very much higher.) Such an exchange is acceptable only where the

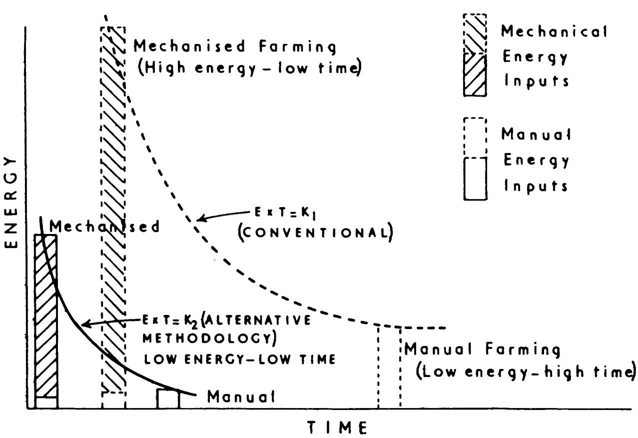

FIGURE 4.2 The concept of 'alternative methodology' in the context of energy and time for conventional and alternative farming systems

Source: Ray Wijewardene, 'Systems and Energy in Tropical Farming', *American Society of Agricultural Engineers*, Paper No. 78-1511 (Michigan, 1978), p. 11.

> alternative fuel is readily available, and the machine for converting it into useful work is within the technical capability of the user. This does not pertain to most of the developing world![11]

Low in time and low in energy technology or methodology has therefore been the mandate at the International Institute of Tropical Agriculture (IITA)[12] for research orientated toward the family farmer, and the objective to 'slide' down to the lower (manual) end of K_2 (graphically illustrated in Figure 4.2) to a system of 'no-till' farming. While in rural areas like India animal power may be difficult to displace where it has contributed to the subsistence economy of countless millions over many generations, 'no-till' techniques associated with mulching have proved dramatic on soils of humid regions. 'No-till' ('zero-tillage') farming techniques however are directed principally at weed control and involve the use of herbicides: IITA 1978 first season data from farmers' fields in Fashol'a, Oyo State, Nigeria, using hand-held zero-tillage tools (including the auto-feed 'jab' planter) for establishing maize interplanted with cowpea on savanna (*Imperata cylindrica* main species) under small-scale (manual) farming conditions, showed a remarkable reduction in man-hours required to establish the interplanted crops – a saving in time and human energy which the farmer could otherwise employ. The point which the IITA stresses is that this was 'still without recourse to the mechanical complexity and very high capital involvement of tractorisation'.[13]

Muckle, however, draws attention for Africa to the traditional agricultural practice of division of labour between men and women, and laments that many items of equipment

> are designed by men and for their use and a result do not find acceptability. There is a considerable scope for

a sociological study into what factors would encourage men to carry out tasks which are traditionally done by women. One of the best examples of how the human factor can go wrong is the bicycle-operated maize mill in countries where women do not ride bicycles yet have the responsibility to grind maize.[14]

Table 2.4 and Figure 2.1 both emphasise the urgency of reducing the energy expenditure load carried by women. Katherine McKee,[15] following fieldwork in West Africa, investigated the possibilities of two types of wind machines – windmills and wind generators. 'The former,' she states, 'can perform slow, high torque work such as pumping water and grinding grain,' both time-consuming and human-energy demanding activities, and she cites the experience of the semi-nomadic Geleb near Lake Rudolf receiving less than 10 in. (25.4 cm) of very variable rainfall per year. Utilising the morning breezes, wind pumps were able to raise 800 gallons (3635 l) of water per hour in 13 m.p.h. winds. Similarly, experiments in The Gambia, taking advantage of sea-breezes near the coast, are in progress to demonstrate that a wind pump can draw water at the rate of 1200 gallons (5452 l) per hour at wind speeds of 10–12 m.p.h. from a 50 ft (15.24 m) well raised into a 10 ft (3.05 m.) high storage tank: the intention is to provide water for vegetable production but the cost, even with a high content of locally-produced materials, was claimed to be prohibitive compared with 'rope and hand', though the time and human-energy saving would be enormous.[16]

It may well be argued by what criteria should these costs be evaluated? In the final analysis, it will be the ability of farm family households to mechanise that will ensure food security – their demand for access to locally-manufactured internal-combustion engines, the small tractor which is not too small that it will dig in or too large that it will bog down; for appropriately designed implements for hand-held, animal or tractor power; for harvesters, crushers, decorticators, silos, irrigation pumps, storage bins; for agri-horticultural transport for truck-farming, and centrally sited fresh food preservation facilities, as urban markets develop.

All these issues require political decisions, what to research in, what to invest in: the 'political will' and organisational capacity to devise and execute policies *leading* to food security and the development of a rural environment in which future generations can find material satisfaction and society enjoy a realistic human energy expenditure balance between work and leisure.

Appendices

APPENDIX I Values used in the Computation of Energy Requirements

	kcal/head per day					
	Males			*Females*		
	Lactation	*Supplement*	*Total*	*Lactation*	*Supplement*	*Total*
0–5 months	600	80	680	600	80	680
6–11	440	520	960	440	520	960
12–17	280	830	1110	280	830	1110
18–23			1250			1250
2 years			1360			1350
3			1560			1520
4			1720			1670
5			1870			1790
6			2010			1900
7			2140			2010
8			2260			2110
9			2380			2210
10			2500			2300
11			2600			2350

12	2700	2400
13	2470	2584
14	2560	2636
15	2647	2636
16	2692	2552
17	2734	2468
18	2734	2394
19	2666	2320
20–39	2647	2320
40–44	2515	2204
45–49	2515	2204
50–59	2382	2088
60–69	2118	1856
70–79	1853	1624

Requirement for adults aged 20–39 calculated at 45 kcal/kg of body weight for both sexes. Requirement for ages 13–19 at specified age calculated as per cent of requirement at age 20–39 for FAO reference man (Table 1.7) in: *Energy and Protein Requirements*, Report of a Joint FAO/WHO *Ad Hoc* Expert Committee (Rome: FAO, 1973) and applied to requirement of Genieri 20–39 year olds. Requirement for ages 40 and over based on FAO's per cent of 20–39 year old reference man (Table 1.5) applied to Genieri 20–39 year olds. Requirement for ages 12 and under, FAO's recommendations for children's requirements (Table 1.7), i.e. to include 'catch-up'.

APPENDIX II Values used in the Computation of Energy Expenditure in Subsistence Agriculture in Genieri Village, The Gambia, West Africa

Activity	*kcal/min. of work*	*Percentage of time in field*		*Walking time min./day*	*Average load carried (kg)*	
		Working	*Resting*		*Under 16*	*16 and over*
			Male labour (58.82 kg/man mean)			
Groundnuts (*Arachis hypogaea*)						
Clearing land before planting	5.3	82	18	24	0.4	0.7
Ridging and planting	6.2	84	16	24	0.4	0.7
Planting on flat	3.4	83	17	24	0.4	0.7
Weeding	4.3	79	21	24	0.4	0.7
Scaring monkeys	6.0	2	98	24	0.4	0.7
Lifting	4.8	70	30	24	0.4	0.7
Windrowing	3.8	61	39	24	0.4	0.7
Stacking	3.7	96	4	24	0.4	0.7
Beating	4.6	67	33	24	0.4	0.7
Winnowing	2.9	67	33	24	0.4	0.7
Late millet (*Pennisetum typhoides* var.)						
Clearing	5.4	82	18	94	0.8	1.3
Planting	3.4	83	17	94	0.8	1.3
Weeding	4.3	83	17	94	0.8	1.3
Harvesting: flattening stems	3.1	90	10	94	0.8	1.3

cutting heads	3.3	91	9	94	0.8	14.6
bundling	3.3	91	9	94	0.8	14.6
Early millet (*Pennisetum typhoides* var.)						
Clearing	5.0	82	18	Negligible	0.4	0.7
Planting	3.4	83	17	Negligible	0.4	0.7
Weeding	4.3	83	17	Negligible	0.4	0.7
Scaring birds	6.0	2	98	Negligible	0.4	0.7
Harvesting:						
flattening stems	3.1	90	10	Negligible	0.4	0.7
cutting heads	3.3	91	9	Negligible	0.4	12.2
bundling	3.3	91	9	Negligible	0.4	12.2
Sorghum (*Sorghum spp.*)						
Clearing	5.3	82	18	29	0.4	0.7
Ridging and planting	6.2	84	16	29	0.4	0.7
Weeding	4.3	83	17	29	0.4	0.7
Harvesting	3.2	90	10	29	0.4	10.7
Maize (*Zea Mays*)						
Clearing	5.3	82	18	Negligible	0.4	0.7
Ridging and planting	6.2	84	16	Negligible	0.4	0.7
Weeding	4.3	83	17	Negligible	0.4	0.7
Harvesting	3.2	90	10	Negligible	0.4	10.7
			Female labour (51.56 kg/woman mean)			
Findi (*Digitaria exilis*)						
Broadcasting and covering	3.7	89	11	18	0.8	1.3
Harvesting	2.8	90	10	18	0.8	10.1

APPENDIX II (*continued*)

Activity	*kcal/min. of work*	*Percentage of time in field*		*Walking time min./day*	*Average load carried (kg)*	
		Working	*Resting*		*Under 16*	*16 and over*
Swamp rice (*Oryza sativa*)						
Hoeing	5.1	59	41	61	0.8	1.3
Pulling grass	3.9	73	27	61	0.8	1.3
Salt test	2.0	90	10	61	—	—
Transplanting	4.2	75	25	61	0.8	4.5
Scaring birds	5.5	2	98	61	0.8	1.3
Harvesting	3.0	91	9	61	0.8	7.7
Upland rice (*Oryza sativa*)						
Manuring	3.0	82	18	40	1.7	2.7
Hoeing and broadcasting	5.3	58	42	40	1.5	2.5
Weeding	3.6	71	29	40	1.5	2.5
Thinning	3.4	71	29	40	1.5	2.5
Lifting	3.4	77	23	40	1.5	5.8
Scaring birds	5.5	2	98	40	1.5	2.5
Harvesting	2.8	91	9	40	0.8	4.4

Notes to Appendix II

Children: all tasks, resting and walking, boys 11–15 age group male adult rate × 0.8, under 11 years × 0.7; girls 11–15 age group female adult rate × 0.8.

Resting in fields: adult males 1.7 kcal/min.; adult females 1.5 kcal/min.

Walking to and from fields: without load, adult males 3.6 kcal/min.; adult females 3.2 kcal/min.; energy cost of load carrying 0.06 kcal/kg of load per minute.

Occasional help by male labour on crops normally cultivated by female labour: female rate × 1.1.

Occasional help by female labour on crops normally cultivated by male labour: male rate × 0.9.

Sources consulted by P. D. Martin: R. H. Fox, 'A Study of Energy Expenditure of Africans Engaged in Various Rural Activities', Ph.D. Thesis, London University (1953); P. G. Phillips, 'The Metabolic Cost of Common West African Agricultural Activities', *J. Trop. Med.*, 57 (1954) 12–20; J. V. G. A. Durnin and R. Passmore, *Energy, Work and Leisure* (London: Heinemann Educational Books, 1967); N. G. Norgan, A. Ferro-Luzzi and J. V. G. A. Durnin, 'The Energy and Nutrient Intake and the Energy Expenditure of 204 New Guinean Adults', *Phil. Trans. R. Soc. Lond.*, B.268 (1974) 309–48; E. Montgomery and A. Johnson, 'Machiguenga Energy Expenditure', *J. Ecology of Food and Nutrition*, 6 (1977) 97–105.

Source of labour data applied to agriculture: M. R. Haswell, *Economics of Agriculture in a Savannah Village*, Colonial Research Studies, No. 8 (London: HMSO, 1953), Appendix VI: number of hours and number of days worked by all farmers, by crop, by operation, by month, sub-divided into age–sex groups ranging from under 10 years to over 60 years, in Genieri village, 1949.

APPENDIX III Values used in the Computation of Energy Expenditure in Non-agricultural Activities in Genieri Village, The Gambia, West Africa*

Activity	*Adult males* *kcal/min.*	*Adult females*
Sleep	1.0	0.85
Routine		
Fetching water		
Walking to well		3.3
Drawing water		4.6
Returning with load		4.3
Fetching wood	4.4	3.8
Pounding foodgrain		4.9
Winnowing foodgrain		2.5
Preparing meals		1.5
Sweeping compounds		3.1
Washing clothes		2.9
Child care		1.6
Eating	1.5	1.3
Personal hygiene	2.3	2.1
Leisure		
Sedentary, e.g. sitting, chatting	1.4	1.2
Light, e.g. standing	1.5	1.3
Moderate, e.g. strolling	2.9	2.5
Heavy, e.g. walking, visiting	3.6	3.2
Energetic, e.g. drumming, dancing	5.5	4.8
Seasonal and part-time		
House repairs	3.5	
Repair of tools and implements	1.8	
Tending animals	3.0	
Marketing and trading	2.1	

*Time spent on non-agricultural activities were locally observed and recorded in 1979 by E. M. Fye, the author's personal assistant 1947–50, 1962, and 1973–4; see Haswell (1975).

Water collection of 1 gallon/capita per day is provided by a one-hour daily journey to the well by all female farmers, each carrying 3.5 gallons. Forty minutes of the hour is spent waiting and chatting.

All grain production pounded and winnowed at 13 min./kg, adjusted seasonally according to consumption pattern.

Wood requirement estimated at 2 kg/capita per day, collected by men at 14 kg per 1.5 hour trip and by women at 10 kg per 1 hour trip, mostly collected on days when no agricultural work is performed.

Total leisure time apportioned as follows:

	Men		*Women*	
	Agricultural work days %	*No agricultural work days* %	*Agricultural work days* %	*No agricultural work days* %
Sedentary	55	40	70	55
Light	20	30	20	30
Moderate	15	15	10	10
Heavy	10	10	—	3
Energetic	—	5	—	2
	100	100	100	100

APPENDIX IV The Energy Content of Some Fuels, Fertilisers and Crop Residues

	kcal/kg
Wood (oven dry)[a]	4700
Substitute fuels	
Crop residues[b]	3600
Dung[b]	2400
Charcoal[a]	7100
Oil	
Motor spirit[c]	11210
Diesel[c]	10890
Paraffin[a]	10400
Fertiliser[d]	
Nitrogen	19100
Phosphate	3350
Potash	2150

Power output of draught animals and energy cost of tractor use

	kcal/hr
Animal power output	
West Bengal draught oxen[e]	448
Tractor use (fuel only)[f]	
Diesel, 49 hp[g]	
Per total hour	41900
Per effective hour	49200
Diesel, 38 hp[g]	
Per total hour	26400
Per effective hour	35600
Diesel, single cylinder 26.5 hp[h]	
Average per tractor meter hour	29200
Operation	
2 furrow mouldboard plough	20600
2 furrow disc plough	16900
Disc harrow	18100
Diesel, 2 wheeled hand tractor 10 hp[i]	16400

[a]D. Earl, *Forest Energy and Economic Development* (Oxford, 1975).

[b]Ashok V. Desai, private communication.

[c]*The Economist Measurement Guide and Reckoner* (London: Economist Newspaper Ltd, 1975): equivalent to 9117 kcal/l. for diesel and 8352 kcal/l. for motor spirit.

[d]G. Leach, *Energy and Food Production* (London: International Institute for Environment and Development, 1975).

[e]A. Makhijani and A. Poole, *Energy and Agriculture in the Third World*, The Ford Foundation (Ballinger, 1975); i.e. power output of 0.7 hp.

[f]Fuel consumption per hour is however influenced by the conditions prevailing in the location of operation, and is an indication of the efficiency of use of power, whereas fuel consumption per hectare indicates efficiency of equipment.

[g]H. Lönnemark, *Multifarm Use of Agricultural Machinery* (Rome: FAO, 1967); fuel consumption recorded in field operations of a government hire service in East Africa.

[h]T. B. Muckle and M. Mukolwe, 'The Purpose and Method of Testing Procedures as Carried Out at the Agricultural Machinery Testing Unit, Nakuru, Kenya', West Africa Rural Technology Meeting, organised by the Ministry of Agriculture, The Gambia and the Commonwealth Secretariat, London, May 1979.

[i]J. Hamid, 'Agricultural Mechanisation: a Case for Fractional Technology' in Tan Bock Thiam and Shao-er Ong (eds), *Readings in Asian Farm Management* (Singapore? Singapore University Press, 1979).

Notes

NOTES TO CHAPTER ONE

1. J. M. Kowal and A. H. Kassam, *Agricultural Ecology of Savanna: A Study of West Africa* (Oxford: Oxford University Press, 1978).
2. Ibid., pp. 215–17.
3. J. V. G. A. Durnin and R. Passmore, *Energy, Work and Leisure* (London: Heinemann, 1967).
4. N. G. Norgan, A. Ferro-Luzzi and J. V. G. A. Durnin, 'The Energy and Nutrient Intake and the Energy Expenditure of 204 New Guinean Adults', *Phil. Trans. R. Soc. Lond.,* B 268 (1974), 309–48.
5. Durnin and Passmore (1967), p. 110.
6. M. R. Haswell, 'Some Factors Affecting Income Yield on Family Farms' in *The Farm Economist*, vol. VII, nos 11–12 (Oxford: Institute of Agricultural Economics, 1954), pp. 432–4.
7. Durnin and Passmore (1967), p. 66.
8. J. H. Lawton, 'The Energy Cost of "Food-Gathering" ', in B. Benjamin, P. R. Cox and J. Peel (eds), *Resources and Population* (London: Academic Press, 1973).
9. M. R. Haswell, *The Changing Pattern of Economic Activity in a Gambia Village*, Department of Technical Co-operation Overseas Research Publication No. 2 (London: HMSO, 1963).
10. Norgan *et al*. (1974) op. cit.
11. M. R. Haswell, *Economics of Agriculture in a Savannah Village*, Colonial Research Study No. 8 (London: HMSO, 1953).
12. Five kcal per minute is the biologists' optimal level (private communication by N. G. Norgan).
13. A. Makhijani and A. Poole, *Energy and Agriculture in the Third World* (Cambridge, Mass.: Ballinger, The Ford Foundation, 1975), pp. 38–9.
14. Applying the low heat energy value of air dry wood of

16 MJ per kg (3824 kcal per kg), Bialy concludes 'the energy used for cooking is about twice the food energy consumed'. For further details, see J. Bialy, 'Firewood Use in a Sri Lankan Village: a Preliminary Survey', unpublished paper, School of Engineering Science, University of Edinburgh (1979).

15. Protein–Calorie Advisory Group (PAG) of the United Nations System, *Women in Food Production, Food Handling and Nutrition: with special emphasis on Africa* (United Nations Publications, 1977), pp. iv, 8–9.
16. The United Africa Company financed the early movement of the crop; see Margaret Haswell, *The Nature of Poverty* (London: Macmillan, 1975), pp. 74–80.
17. D. P. Gamble, *Economic Conditions in Two Mandinka Villages: Kerewan and Keneba* (London: Colonial Office, 1955).

NOTES TO CHAPTER TWO

1. J. Saidy, 'The Gambian Village that Missed its Chance to make History', *The Gambian News Bulletin*, No. 110, 16 September 1976.
2. Haswell (1953).
3. The process by which all animals and pre-agricultural man obtained their food.
4. J. H. Lawton in *Resources and Population* (1973).
5. M. R. Haswell, *Tropical Farming Economics* (London: Longman, 1973), p. 61.
6. Based on values computed in Appendix I.
7. Haswell (1973), p. 103.
8. Norgan *et al*. (1974).
9. M. G. M. Rowland, A. A. Paul, A. M. Prentice, E. M. Müller, M. A. Hutton, R. A. E. Barrell and R. G. Whitehead, 'Seasonal Aspects of Factors Relating to Infant Growth in a Rural Gambian Village', paper read at a conference on 'Seasonal Dimensions to Rural Poverty' held at the Institute of Development Studies, University of Sussex and the Ross Institute of Tropical Hygiene, 3–6 July 1978.
10. Paper presented at the West Africa Rural Technology Meeting and published in *Proceedings of the West Africa Rural Technology Meeting, Yundum, The Gambia, and Dakar, Senegal*, 14–22 May (London: Commonwealth Secretariat, 1979).

NOTES TO CHAPTER THREE

1. See Table 1.2 (p. 7).
2. Norgan *et al.* (1974), pp. 318, 321–2.
3. Derived from Haswell (1975), pp. 39, 101.
4. G. M. Culwick, *A Dietary Survey among the Zande of the Southwestern Sudan* (Ministry of Agriculture, Sudan Government, 1950).
5. Gamble (1955), p. 1.
6. Ibid., pp. 1–2.
7. J. A. DeBoer and D. E. Welsch, 'Constraints on Cattle and Buffalo Production in a Northeastern Thai Village', in R. D. Stevens (ed.), *Tradition and Dynamics in Small-Farm Agriculture* (Iowa: Iowa State University Press, 1977), pp. 122–4.
8. This refers to those four of the six compounds drawn in the randomised sample in 1973 which were in existence in 1949: detailed records of all inputs and outputs were obtained in 1973–4 for these households; see Haswell (1975).
9. See Table 2.1.
10. J. Saidy, 'The Gambian Village that Missed its Chance to make History', *The Gambian News Bulletin*, No. 110, 16 September 1976.
11. M. Sharma, *The Politics of Inequality*, Asian Studies at Hawaii, No. 22 (1978).
12. Ibid., p. 118.
13. Between 1974 and 1979 a quarrel developed over debt repayments between this household (one of the sample households in the 1973–4 re-survey: see Haswell, 1975) and the traditional village money-lender, and by 1979 the entire family had left and the compound found to be abandoned.
14. W. R. Rufener, 'Cattle and Water Buffalo Production in Villages of North-east Thailand', unpublished Ph.D. dissertation, University of Illinois, September 1971.
15. DeBoer and Welsch (1977).
16. Measurements made during the 1973–4 re-survey for the author by the late A. K. Rahman, MBE, Medical Research Council Laboratories, Fajara, The Gambia.

NOTES TO CHAPTER FOUR

1. Durnin and Passmore (1967).
2. H. Bunting, 'Towards a Better Age', *New Scientist*, 29 March (1979), 1044.
3. F. Cancian, *Change and Uncertainty in a Peasant*

Economy: The Maya Corn Farmers of Zinacantan (Stanford, Calif.: University of California Press, 1972).

4. H. Ruthenberg, *Farming Systems in the Tropics* (Oxford: Oxford University Press, 1971).
5. Lawton (1973) states: 'assuming that an average cereal crop will receive approximately 1.5 cwt of N fertiliser per acre per annum (the actual figure is very variable; some like barley on rotation after sugar-beet may receive none) and since the energy cost of manufacturing synthetic nitrogen fertiliser can be as high as 35×10^6 kcal per ton, the cost of manufacturing the fertiliser used on the crop comes to an additional 2.6×10^6 kcal per acre per annum. This alone is nearly half the energy yielded by the crop it is used to fertilise.'
6. *Genetic Evaluation and Utilization Program*, IRRI Annual Report (1975), pp. 74–81.
7. Bunting (1979), p. 1045.
8. R. Wijewardene, 'Systems and Energy in Tropical Farming', *American Society of Agricultural Engineers*, Paper No. 78-1511 (1978).
9. H. Metrick, *Oxenisation in The Gambia* (London: Ministry of Overseas Development, 1978), pp. 11–12.
10. *Pilot Farming Scheme Proposal* (April 1979) kindly made available by Pierre A. Tomson, FAO Farm Management Advisor.
11. Wijewardene (1978).
12. Ray Wijewardene is Agricultural Engineer, Farming Systems Program, IITA.
13. Wijewardene (1978).
14. Muckle and Mukolwe, paper presented at the West Africa Rural Technology Meeting, and published in *Proceedings of the West Africa Rural Technology Meeting, Yundum, The Gambia, and Dakar, Senegal*, 14–22 May (London: Commonwealth Secretariat, 1979).
15. 'Windpower in Sub-Saharan Africa: Potential, Socio-economic Impact, and Pitfalls', Graduate Program Credit paper submitted to the author's course on 'Topics in Modernisation and Development: Alternative Strategies for Rural Development' when the author was Visiting Lecturer at the Woodrow Wilson School of Public and International Affairs, Princeton University, N.J. (Spring Term, 1978).
16. Privately communicated at the site during the West Africa Rural Technology Meeting held in Yundum, The Gambia, and Dakar, Senegal, sponsored by the Commonwealth Secretariat (1979).

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Index