Agricultural Development and Nutrition
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Edited by Arnold Pacey and Philip Payne
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1 Food systems and needs
Changes have taken place in views of malnutrition in the last two decades, and these are outlined. Two examples of new approaches are given – the current debate about human energy requirements, and ecological studies of farmers’ energy balance. Malnutrition does not arise from isolated single causes, but from dysfunction in the ‘food system’. Examples are given of the interaction of health, work and family structure, in the system

2 Defining malnutrition
Even the identification of ‘malnutrition’ as a state, is not simple. Physical definitions of malnutrition can be set lower or higher according to their intended purpose. These purposes may range from ‘selecting the most malnourished individuals for treatment’ to ‘selecting groups to
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receive certain benefits'. The policy implications of varying classification methods are discussed.

3 Energy and protein requirements

At this point the question 'how much food do people need?' is discussed. Man's needs for energy and nutrients have often been calculated, with the use of various assumptions. These are examined, with the question 'What is the nature of successful and unsuccessful adaptation to variable and low food intakes?'

4 Food system indicators

Chapter 1 introduced the general idea of a 'food system', and Chapters 2 and 3 outlined current thinking on how utilisation of food, and human outcomes in that system may be evaluated. Data available for describing other parts of the system are now reviewed. Indicators of individuals' nutritional state were discussed in Chapter 2; here they are put alongside other indicators, and the use of standard values and cut-off points is reviewed

Part Two The Causes of Malnutrition

5 Multiple causes in malnutrition

Little needs to be added to this chapter's title, by way of summary. Having outlined the 'food system', it is logical to consider some of the interacting dysfunctions which lead to malnutrition. Illness and poverty are important keywords.

6 Functional classes and targeted policies

It is one thing to outline the causes of malnutrition, and another to direct specific policies towards the malnourished. This is called targeting. One way to link explanation and
action is to use an analytical framework which is itself action-oriented. ‘Functional classification’ is such a framework. It provides descriptions of population groups which made administrative sense, and which enable agriculture, nutrition and health policies to be better targeted on situations which give rise to malnutrition. Examples of the implication for some interventions are discussed.

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‘Nutrition in agriculture’ is not just about increasing food production. In this chapter we discuss the contradiction between increasing production and declining consumption and the concept of people’s entitlement to food. We review the effect of agricultural development strategy on the social status, labour opportunities, and hence the nutrition of different agrarian classes.

8  Markets and food availability  163
Markets are an important component of the ‘food system’, governing some people’s access to food and the returns to others’ labour. Market systems may behave in many different ways but they normally work to the advantage of those classes who are least likely to become malnourished. Policies on food price supply and processing technology tend to favour the urban rich rather than the rural poor. We give two important cases where nutritional justifications for these policies are argued after the event rather than before. These ‘justifications’ are scientifically invalid and socially and culturally irrelevant.
9 Nutrition interventions
Chapters 7 and 8 have shown that in practice, government policies in agriculture and health have considerable impact on nutrition – impact which is often not recognised. On the other hand, several kinds of government-sponsored action are regarded characteristically as ‘nutrition interventions’. Yet under some circumstances they may have little impact on malnutrition, as is indicated in this chapter.

10 Professional roles and research
What have agricultural and nutritional workers to contribute to one another’s understanding of malnutrition, and to programmes which may reduce its prevalence? They can exchange insights derived from their characteristic approach to problem analysis; this can help to avoid narrow oversimplified ‘solutions’. Research can be interactive – and not only among different classes of researcher but among researchers and ‘subjects’. It is important, if we aim to study and manipulate the ‘food system’, to do so as advocates for those who are disadvantaged within it.

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During the decade which followed the World Food Conference held in 1974 in Rome, much debate, research and evaluation has focused on the impact of development strategies on the prevalence of malnutrition. Within the UN system the Food and Agriculture Organization (FAO) and the Children’s Fund (UNICEF) have been actively involved in promoting new approaches in this field. FAO has been at the forefront of recent efforts to improve the nutritional impact of agriculture and rural development. UNICEF’s well-known work guides and supports many types of development that relate to child welfare and services, including the problems of access to food and feeding of children.

There is a unanimity of opinion in all circles that the agriculture sector lies at the centre of any solution to the world’s food problems. Yet the sobering thought that has become all too evident in recent years is that food production alone is not the answer. Rapid progress in production and exports of food commodities are found to co-exist with malnutrition even in the same areas of certain countries. Therefore while increased food production is an essential precondition, improved distribution is also necessary to overcome inadequate food consumption and malnutrition. The work that remains to be done is the application of suitable approaches through which agriculture and rural development can prevent the waste of human resources and potential which is caused by malnutrition.
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This text, prepared by the Nutrition Policy Unit of the London School of Hygiene and Tropical Medicine, is an exposé of the many food consumption-related problems which need to be considered alongside agricultural production issues in development. It examines those social, environmental, economic and political factors that determine the degree to which people have access to food and can assimilate its nutrients. After reviewing the present scientific knowledge of energy, nutrient requirements and human growth, the authors concentrate on the many obstacles rural families face in trying to satisfy their basic food needs.

They argue for a balanced agricultural and rural development which would alleviate not only the technical constraints to increased production but also those many social, economic and political impediments that prevent people from having access to the foods that are produced.

This compilation of materials originally prepared for a UNICEF/FAO/Indian Council of Agricultural Research Workshop, is therefore a most important contribution to the thinking that has evolved recently about an interdisciplinary approach to food and nutrition problems. It will stimulate agriculturalists, rural development experts, food and nutrition planners and nutritionists all over the world in devising development strategies that are as concerned about impact as they are about outputs.

FAO and UNICEF are pleased to have supported the preparation of this manuscript and, while not necessarily endorsing its every argument, are gratified to be associated with a book which provides a modern and responsible vision of the basic themes and questions which they consider must guide development. The text is intended to stimulate interdisciplinary thought, discussion, research and action at the village, district, national and international level. By questioning the weaknesses of present approaches it cannot help but challenge all of us to search for more effective answers to food and nutrition problems in future development.
Starting in 1971, the Government of India, with the assistance of FAO, UNICEF and UNDP, embarked on a long-term programme to extend and reinforce the subject of human nutrition in higher education. The programme envisaged the teaching of food and nutrition subjects in agricultural, veterinary and home science colleges, and these institutions have been assisted in building up food and nutrition departments to undertake training and research in subjects related to nutrition.

Since 1980, under the title ‘Education in Food and Nutrition in Agricultural Universities’ (EFNAG) the programme has developed both in direction and content.

The general objective remains the same: to improve the nutrition of rural families and the means of achieving this is through three main aims:

1. to introduce a wider understanding of nutritional issues in the agricultural sector in order to incorporate nutritional considerations in agricultural programmes and hence bring about better nutrition;
2. to promote an understanding of the factors contributing to malnutrition, especially those related to poverty, with special reference to infant malnutrition;
3. to develop a more comprehensive view of training in agriculture and allied subjects that includes elements of food and nutrition education and basic services for children: this broader view should encompass the human aspects of agriculture, such as
development communication, extension methods, programme planning and food planning.

Of particular concern has been the need to strengthen the capacities of agricultural universities to include a nutrition dimension into the training of post-graduate students, and to lay the foundations of an expanding programme of applied and operational research in areas which link the production of food with the nutrition of rural people.

As an expression of that concern, the Indian Council of Agricultural Research, with the sponsorship of FAO and UNICEF, organised a workshop at Haryana Agricultural University in April 1982. The Nutrition Policy Unit of the London School of Hygiene and Tropical Medicine was invited to propose a programme of topic areas; to provide background working papers for the review sessions; and to conduct and co-ordinate the proceedings generally.

The objective of the workshop was to review in depth those aspects of the science of food and nutrition which are relevant to agriculture and to rural development, and similarly those aspects of agricultural change which have a direct or indirect impact on the nutritional condition of human populations. With this review as a background, the workshop was then to determine priorities for the inclusion of nutrition topics into programmes of post-graduate training in agriculture and home science, and hence to provide guidelines for future curriculum and research programme development. This book has been based for the main part on material presented to the workshop, and on a record of the discussions which ensued.

It is conventional to preface books of this kind with broad statements about the critical importance of improving the nutritional conditions of human populations, and of accepting that such improvement should be an explicit objective of development. It is logical to assume that the pace and direction of agricultural change will be a critical factor in achieving this objective: more people consuming a better diet must have implications for food production, and more effective deployment of the means of production should be reflected in more people able to afford to eat adequately.
However, having indicated this fundamental relationship, it has usually been assumed that the objective of improving the nutrition of human populations at the same time as improving the practice of agriculture will be achieved automatically through bringing about an interchange between the two academic disciplines of nutrition and of agriculture. But what exactly should be the nature of that exchange? Should it be factual knowledge? Will malnutrition be reduced if agricultural students in future know that there are 10 amino acids essential for health, or that beans contain more protein than rice, or that vitamin A deficiency can be prevented by eating green vegetables? Or should the exchanges be of concepts, of the nature of the processes, social and economic, as well as physiological, which result in malnourished individuals?

We believe that it is particularly important at this time to take a critical look at how the two disciplines, agriculture and nutrition, should be expected to interact. We hope that this will be especially fruitful in the context of post-graduate activities, since this is traditionally the area in which subjects develop and new concepts are formed. Not the least reason for the timeliness is that despite the widely acknowledged importance of adequate nutrition as a basic component of human welfare, and despite the manifest success of agriculture in supporting the growing populations of the world, malnutrition persists. We have both more food and more destitute and hungry people. How can the connection be made between our growing technical capacity to generate wealth from the soil on the one hand and our understanding of the biological and social needs of man for food on the other? One thing is certain, there are no easy answers, and the reader of this book will search in vain for prescriptions, progress will come only through the realisation that the real problems and solutions lie in the nature of social and political institutions and the human relationships that underlie them. For some people this realisation is painful, and leads either to a rejection of science as irrelevant, or to a retreat into the more comfortable distractions of academic research. We shall be happy if this book helps to strengthen the view that curiosity about the way the world works, and the urge to extend
knowledge about what things are possible in the world through analysis and criticism can be applied to the solution of the problems that give rise to hunger.

Peter Cutler
Elizabeth Dowler
Barbara Harriss
Philip Payne
Erica Wheeler

Those whose names appear above are the members of the Nutrition Policy Unit of the Department of Human Nutrition at the London School of Hygiene and Tropical Medicine. All of them contributed material to the book. It could not have been written, though, without the help of many other people, in particular N.S. Jodha, Claire Kelly, David Nabarro, Adam Pain, Paul Richards, John Rivers, Young Ok Seo and Anne Thomson, who either work with us, or generously allowed us to use their work. We are also grateful to Madeleine Green and Barbara Kenmir who typed the manuscript.

Above all the book is the result of the integrating perspectives and unstinting labour of Arnold Pacey.

Our grateful thanks go to Margaret Khalakdvia and her staff at Haryana Agricultural University, and to Franciso Coloane of UNICEF for their outstanding hospitality, constant encouragement and careful arrangements which ensured the smooth running of the workshop.

The costs of editing and preparation of the manuscript were borne by FAO and UNICEF. However, neither of these organisations are responsible for any of the views or opinions expressed herein.

Philip Payne
‘The people are crying out for bread and we are going to give them statistics.’

*John Boyd-Orr in 1945 on proposed terms of reference for FAO (see Orr 1966, pp. 20, 162)*
1 Food systems and needs*

Changed perspectives

During the last three decades, the application of nutritional science to the problems of hunger and malnutrition has passed through a phase of great confidence and hope, followed by one of increasing uncertainty and doubt. Twenty years ago, a book such as this would have discussed well-defined nutritional interventions, aimed at achieving some equally well-defined nutritional objectives. Very little space would have been devoted to questioning the validity of those objectives, or the effectiveness of the programmes themselves. In so far as progress towards reducing malnutrition was acknowledged to be slight, this would have been interpreted as showing the need for more extended programmes, hence for more resources, and especially for more trained people to be deployed.

The connection between nutrition and agriculture would have been presumed to rest on a number of premises: that hunger would be eliminated if there were an increase in the overall production of food; that malnutrition is often caused by deficiencies of specific nutrients (e.g. protein) and that this can best be countered by emphasis on the production of certain kinds of foods, or by fortification or enrichment of staples; that poor

*This chapter is based mainly on material prepared by Philip Payne; see Rivers and Payne (1982) and Payne (1982).
nutrition is often the result simply of ignorance; and hence there is a general need to educate people on how to make proper use of the resources available to them. Infectious disease, though recognised to interact with malnutrition, would be regarded as essentially a separate problem to be dealt with by specifically designed programmes.

There has been a fairly radical change of viewpoint over the last two decades. This has been broadly for three reasons. Firstly, there has been a change in concept: malnutrition, previously regarded as something caused by single physical factors, is now accepted as having multiple causes, many of which are closely linked to the conditions of inequality of resources, or poverty, and of social discrimination. Changes in the system of food production which leave these conditions unchanged will also leave malnutrition unchanged or may even aggravate it. Indeed, we have witnessed some countries becoming net exporters of food, while sections of their populations remain inadequately fed, or even experience famine. In addition to this, among young children especially, malnutrition is so intimately related to infectious disease that it makes no practical sense to pursue programmes aimed at improving food consumption without also tackling at least some of the environmental causes of such disease. This may lead the nutritionist to encourage improvements in water supply, sanitation, housing and domestic fuel.

The second reason for a changed perspective is that there has been progress in our understanding of the physiological and biochemical processes underlying malnutrition. We now know that man has the capacity to adapt to a fairly wide range of dietary situations, and that only when that adaptive capacity is stretched beyond its limits does the body fail to maintain its functional capacity,* and malnutrition ensues.

Thirdly, there is a growing awareness that many of the more

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*Functional capacity here is taken to mean all aspects of the behaviour of an individual in response to the environment, such as physical and mental activity, response to stress, disease etc. This should not be confused with the term 'functional classification' which is used in later chapters.
Food systems and needs

conventional types of nutrition programme have not achieved what was hoped of them. Interventions such as the promotion of high-protein crops, food delivery systems aimed at young children, and projects for educating people about the nutritional value of foods, have often been totally ineffective, or effective only as short-term palliatives. Frequently they have also distracted attention from the need to attack more fundamental problems.

It is in this context of doubts and questioning about past ideas that we need to review the relationship between knowledge of nutrition and planning for agriculture. We believe that from a basis of analysis and criticism, we shall be able to begin a synthesis. But the ideas that will carry us forward will be different from those of the past. They will include ideas about food systems, about the epidemiology of malnutrition, and about ‘livelihoods’. They will also include suggestions about the use of indicators, and ways of understanding the multiple causes of illness and deprivation. These and other concepts give us a new point of departure, so that we should not expect simply to substitute a new set of nutrition programmes, more potent and more efficient than the old – a set of ‘right’ answers to substitute for the ‘wrong’ ones. There are no simple answers, and whatever it is that a nutritional approach to human problems can provide, it is not likely to give us any short-cut solutions or technical fixes. The problems of malnutrition will be overcome as and when we overcome those of poverty, deprivation and disease. But we are all concerned with these, and therefore we could well begin by asking: what is so special about the nutritional viewpoint? Why should we be especially sensitive about nutritional needs rather than economic or social needs?

One clear lesson from the past is that when a particular problem at first sight requires nutritional expertise for its solution, this analysis is not always borne out by closer critical analysis. The skill and integrity of a profession rest at least as much on its willingness to show when it cannot and should not play a key role, as on its ability to demonstrate the effectiveness of its methods when they are relevant. However, there is a general case for concerning ourselves with nutrition and with
food as a fundamental aspect of agricultural development, and this rests on two propositions.

The first identifies the nutritional status of a person as both the outcome of the process of acquiring, consuming and utilising food, and one of the critical inputs to that process: the food a woman or a man eats decides the amount of effort she or he can afford to invest in order to secure food in the future. If we can measure nutritional status, therefore, we have a unique index of the impact upon individuals of the whole system of production, utilisation and exchange.

The other proposition is related to this: it is that, of all the symbols and objects of social exchange, food is arguably the most basic. Co-operation in the acquisition of food, and its sharing among the members of a family marked the beginning of the social evolution of mankind. The extent of an individual’s integration with society can be measured by the adequacy and security of his or her ability to produce, control, purchase, borrow or otherwise acquire food (i.e. his ‘food entitlement’ (Sen, 1981)).

This book is focused on a range of topics which impinge upon different stages and processes operating within the food ‘system’; that is to say, the system comprising the production, distribution, consumption and biological utilisation of food. Figure 1.1 shows, in a much simplified way, a few of the key relationships and processes which will be discussed. It is not intended as a complete definition of the ‘system’, but more a starting framework within which we may wish to elaborate certain areas. Then, by understanding how people become malnourished in terms of processes within the system, we may be better able to make statements about who such people are, and to describe their relationship with production and the basis of their entitlement to food. Malnutrition, in this context, is a symptom or signal that certain processes are regularly occurring in the lives of people which, if disregarded, will result in the continued generation of sickness and physiological impairment.

*Full references quoted in the text are contained in the Bibliography beginning on p.220.*
Analysis of the nutritional problems within a society may therefore have implications for agriculture at many different levels. At one level, it may consider the impact of agricultural change on the ability of people to earn an entitlement to food. To produce more, but at a cost many people cannot afford, may be self-defeating. An orientation of technology to production, which neglects problems of consumption, needs to be corrected. At other levels, the analysis points to the need for an integrated approach by planners to the development of land resources for food, for fuel and for cash crops. It underlines the need to improve the domestic environment as well as to plan resource inputs to agriculture. It may also indicate the need to avoid certain directions of change because of the danger of aggravating
the risk of malnutrition, or may at least demonstrate the cost of that effect in assessing policy choices.

These, then, are the themes of this book. Our starting point is actually near the bottom of the diagram, which is where we find the more usual focus of food and nutritional science. The traditional emphasis continues in much teaching and research, that is to say on the properties and uses of foods rather than on the nutritional problems of populations. Part of the purpose of this book is to present a reverse perspective – to put the problems of people first and see what questions they prompt about nutrition. To reverse the traditional perspective of nutrition in this way is not, of course, to say that everything done previously was mistaken. What we would argue, though, is that if one constantly approaches a subject from the same point of view, important insights may be missed, and received views may not be adequately questioned. For example, to tackle the question of how much food human beings require we first ask what kind of life those individuals lead, and what physiological functions, therefore, does their food intake have to support?

If the science of nutrition has any central concept, it is surely this notion of nutrient requirements. The initial impetus for the subject came from nineteenth-century attempts to define those requirements, and in many quarters, that approach is still important. The process of revising estimates of energy and protein requirements continues unabated, and the problem of fixing them remains apparently unresolved. What has changed since the early days is that originally pronouncements about nutrient requirements were made by individual scientists and were based on their own research; now, similar pronouncements emanate from committees of experts convened by governments or international agencies and to a large extent reflect the experts’ selection of scientific evidence and of theory (Rivers and Payne, 1982).

Despite the authority and influence associated with some of these figures, the concept of a ‘nutrient requirement’ remains somewhat intangible. Discrepancies between estimates, and the revisions that are made from time to time, do not seem to reflect differences in technique or theory, but may have more to do with
political pressures or changing social valuations of the acceptability of particular intake levels. For example, successive estimates of food energy requirements made by the US National Academy of Sciences for a moderately active man with a body weight of 70kg have been as follows (NAS 1943, 1958, etc.):

12.5 MJ (3000 kcal) in 1943;
13.4 MJ (3200 kcal) in 1958;
11.7 MJ (2800 kcal) in 1968;
11.3 MJ (2700 kcal) in 1974.

The 16 per cent fall in estimated requirements since 1958 is not the result of improvements in the process of estimation, nor of any factor such as change in levels of activity, but must be attributed more vaguely to climates of opinion and perhaps concern about obesity.

Nonetheless, the questions ‘how much food does a man/woman/child need?’ and ‘what are the reasons for and consequences of failing to meet that need?’ remain central to agricultural development. We set out below some of the issues involved in answering them and the problems raised thereby. We use a series of short case studies (from different parts of the world) to illustrate them.

**Food energy and agrarian ecology**

Lack of progress in attempts to define human energy and nutrient needs illustrates one reason why it is useful to think in terms of the level of nutrition needed to maintain the functional capacity of the body. If we take the traditional view of a nutrient requirement as the minimal amount of nutrient needed to maintain a given physiological state such as ‘health’, then we are faced with the problem of specifying that state. And although health and well-being are certainly to be valued as social goals, the utility of health as a reference criterion is limited by our inability to define a state of ideal health which an adequate nutrient intake should sustain.

The social nature of the definition of health has been
frequently discussed elsewhere (Illich, 1976; McKeown, 1979), its use as a criterion for fixing energy requirement is particularly complicated by the fact that it seems impossible to identify a healthy population. As one official body states, most of their recommendations on food energy are based on measurements of what actual populations eat, assuming that these populations are healthy. However, they point out that: ‘Many groups of people ... living in the industrialized countries are obese. On the other hand some groups living in developing countries are small in stature, light and thin, yet may not be physically less healthy because of their different body size’ (FAO/WHO, 1973).

Another approach is to attempt the definition of energy requirement in terms of the maintenance of a specified physiological state, disregarding notions such as ‘health’ and this leads to the apparently more precise concept of ‘nutrient balance’, a deceptively simple notion which has been widely applied in animal nutrition (Blaxter, 1967).

Obviously, in the non-pregnant adult animal, nutrient intake and expenditure must match if the body content of the nutrient is not to rise or be depleted. The problem is that balance can be achieved over a range of intakes through adaptations of various kinds. Thus the question ‘which level of nutrient balance is preferred?’ is inescapable, and can only be answered by referring back to ‘health’.

The balance method is thus no more objective than the health criterion. The decision about what level of equilibrium or for children, what rate of growth, and hence what degree of positive balance, will be regarded as a norm remains entirely subjective unless we are prepared to specify a particular set of desired functions and a set of undesirable symptoms we wish to avoid. The decision which is usually made (albeit not always explicitly) is to say that we prefer the levels and growth rates which are typical of western developed countries, though we are discovering that these are not without disadvantage for health.

It is in order to avoid such ambiguities and difficulties that this book uses ‘functional’ criteria of the adequacy of food intakes. From this point of view, malnutrition is defined as a state in which the physical function of an individual is impaired to the
Table 1.1  Energy intakes of New Guinea adults

<table>
<thead>
<tr>
<th>Village</th>
<th>Body weight</th>
<th>Energy intake per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg</td>
<td>MJ</td>
</tr>
<tr>
<td>Kaul (coastal location)</td>
<td>males 56</td>
<td>8.12</td>
</tr>
<tr>
<td></td>
<td>females 47</td>
<td>5.94</td>
</tr>
<tr>
<td>Lafa (highland location)</td>
<td>males 57</td>
<td>10.54</td>
</tr>
<tr>
<td></td>
<td>females 51</td>
<td>8.79</td>
</tr>
</tbody>
</table>


point where she or he can no longer maintain adequate performance in such processes as growth, pregnancy, lactation, physical work, or resisting and recovering from disease. The notion of an adequate level of performance is itself not a simple one. However, it avoids the rather greater difficulties of talking about adequate levels of health if, in the first instance, we use it to mean the achievement of a sustainable mode of existence. Thus, for example, to avoid malnutrition, members of a farming family must be able to do physical work on their land and crops, sufficient not only to secure their immediate food needs, but to sustain productivity over long periods, and to survive through bad years as well as good. They must in addition be able to adjust total production from their resources to keep pace with the demographic changes (numbers of dependants and number of productive adults) in the family itself.

In taking this approach, we regard dietary energy as the most likely limiting factor. This does not imply that vitamin and other deficiencies do not occur, or are of minor consequence. Rather we are suggesting that the avoidance of energy constraints is a necessary even if not always a sufficient condition for avoiding malnutrition.

In the context of agriculture, the problem of energy deficiency is quite a subtle one, partly because of the wide range of different farming ecologies that can be successfully exploited, and partly because we have to look at equilibrium situations where the working capacity of adult family members is both the outcome of
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a particular level of food consumption, and the labour input to the production system which generates the food. Viable equilibrium can therefore be maintained over a range of levels of intake and output. As an example, Table 1.1 shows the average food energy consumption levels of men and women in two villages in New Guinea.

The people of both villages had similar and generally good states of health, without any signs of malnutrition. However, members of the coastal community needed to devote only small amounts of labour to their gardens, and despite a plentiful source of fish, rarely bothered to go and catch them. Most of their day was spent in leisure and socialising. The highland community, by contrast, lived and worked on steep mountain slopes, and spent several hours a day in fairly heavy labour. The two situations are both successful from the point of view of health and survival. Food energy needs are different, however, and if malnutrition did occur at some future time because of limited land access, or because of some climatic event, it would do so at different levels of food consumption.

Consider now rice cultivation. It is estimated that dryland rice requires approximately 130 man-days of labour input per hectare in one environment (Bayliss Smith 1981), corresponding to a work input of about 390 MJ per hectare. It will yield on average about 15,000 MJ net edible yield of rice – about 1000 kg – so the ratio of energy output to input is 38:1. This is not an unusual figure, since according to Leach (1975) energy ratios for pre-industrial crops are generally in the range from 13 to 38. When food energy production in a pre-industrial society is at or below the lower end of that range, it is likely that not enough food is being produced to support non-agricultural work such as water-carrying or house-building, and to support non-working members (old people and children), so malnutrition in the sense of functional failure becomes increasingly probable.

Changes in energy needs over time

At this level of analysis, the picture presented is of a simple,
static equilibrium, with energy flows averaged over time, and no account taken of the effects of either regular seasonal factors, or irregular unpredictable hazards. Seasonal factors may impose two kinds of restriction, in the first place related to time intensity. Certain tasks must be carried out in specific seasonal time periods and this may impose a lower limit on the number of working adults or their equivalents per hectare necessary to secure a given type of crop. Secondly, work intensity may impose limitations bearing in mind that the physical work required for certain tasks may be much greater than average and may only be sustainable by individuals with a high level of physical fitness, i.e. good nutritional status, and freedom from disease or injury.

Further, agricultural seasons are not always the same; there are good years and bad years. Survival in bad years means either the ability to achieve a surplus during good years, with some means to carry this over as stored food, as cash, or as assets which may be collateral on loans, or some other opportunities for converting labour resources to food or cash by alternative employment.

An additional, longer-term result of the passage of time is that the size and demographic structure of the family will change: total food needs increase steadily as successive children are born, but later the children grow up and contribute to the family's labour power. Together, then, the influence of seasonal cycles and family development is such that we need a dynamic view of the whole food system, of the functions which take place within it, and of the environmental and temporal changes which form its context.

A village in Burkina Faso, West Africa, where millet is the principal crop, illustrates one kind of sharply seasonal contrast. In this area, the dry season is a long one; it is followed by a relatively short period when the soils are sufficiently softened by the rain to be workable, and when crops must be sown. During this period, therefore, long hours of labour are necessary. The time intensity and work intensity of the effort people must make are both high. Human energy expenditures are, as a result, comparable to those found only in coal mining in more industrialised economies. By contrast, during the dry season there is little work to be done and
Table 1.2 Energy expenditures of farmers in an Upper Volta village

<table>
<thead>
<tr>
<th></th>
<th>Energy expended per day</th>
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<tbody>
<tr>
<td></td>
<td>MJ</td>
</tr>
<tr>
<td>Dry season</td>
<td></td>
</tr>
<tr>
<td>women</td>
<td>9.7</td>
</tr>
<tr>
<td>men</td>
<td>10.1</td>
</tr>
<tr>
<td>Wet season</td>
<td></td>
</tr>
<tr>
<td>women</td>
<td>12.1</td>
</tr>
<tr>
<td>men</td>
<td>14.4</td>
</tr>
</tbody>
</table>

Sources: Bleiberg et al. (1980); Brun et al. 1981.

energy expenditures are low. The men in particular have a very sedentary lifestyle and their energy expenditure drops sharply (Table 1.2).

This example shows that when we look at energy expenditure and food supply on a single occasion, or indeed, averaged out over a year, we can tell very little about the adequacy of diet, or the likelihood of malnutrition. For these West African villagers, malnutrition might consist of inability to meet peak labour demands because of either insufficient food available to balance expenditure at that time, or because of body stores insufficiently replenished since the previous working season.

In all probability, people using this kind of production system face problems of both time and work intensity, and their responses are partly behavioural and social, partly physiological: the periods of peak work output, which may be quite short in time, are sustained partly at the expense of body energy stores. Thus people lose weight, and then regain it during a subsequent period when work output is dramatically reduced, but food intake is maintained at the previous level, or even increased. Figure 1.2 shows these effects as they have been observed in Gambia. This country is also in West Africa, and the seasonal ecology is similar (though less extreme) to that of Burkina Faso (Fox 1953). Periods of peak energy expenditure are associated with harvesting, and with soil preparation and planting.

Obviously, there are physiological limits to the extent of this cyclic process: if too much weight is lost, perhaps because of a
Figure 1.2  Fluctuations in adult body weight by season in a Gambian village

Source: Fox 1953
### Table 1.3 Analysis of labour time for different operations of cultivation of HYV and TV paddy in North Arcot District, Tamil Nadu, India

<table>
<thead>
<tr>
<th>Agricultural operation</th>
<th>Percentage of person-days spent in the operation</th>
<th>Additional person-days for HYV over TV per hectare</th>
<th>Percentage of female labour used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HYV</td>
<td>TV</td>
<td>HYV</td>
</tr>
<tr>
<td>Ploughing</td>
<td>18</td>
<td>18</td>
<td>5.9</td>
</tr>
<tr>
<td>Manuring</td>
<td>2</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>Fertiliser application</td>
<td>0.5</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Pulling seedlings</td>
<td>4</td>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>Transplanting</td>
<td>15</td>
<td>15</td>
<td>6.2</td>
</tr>
<tr>
<td>Weeding</td>
<td>12</td>
<td>12</td>
<td>3.7</td>
</tr>
<tr>
<td>Pesticide application</td>
<td>0.2</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Harvesting and threshing</td>
<td>32</td>
<td>28</td>
<td>24.8</td>
</tr>
<tr>
<td>Irrigation</td>
<td>13</td>
<td>15</td>
<td>1.5</td>
</tr>
<tr>
<td>Others</td>
<td>3</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100</td>
<td>100</td>
<td>41.2</td>
</tr>
</tbody>
</table>

**Labour energy input per ha (MJ)**

<table>
<thead>
<tr>
<th></th>
<th>HYV</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>830</td>
<td>710</td>
<td>120</td>
</tr>
</tbody>
</table>

**Net edible rice per ha as food energy output (GJ)**

<table>
<thead>
<tr>
<th></th>
<th>HYV</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>33,000</td>
<td>24,000</td>
<td></td>
</tr>
</tbody>
</table>

**Energy ratio**

<table>
<thead>
<tr>
<th></th>
<th>HYV</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>40:1</td>
<td>34:1</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. The labour required for harvesting and threshing could not be separated in many instances.
2. The work required for irrigation involves switching on pump sets, waiting for electricity, or operating the kavalai.
3. Labour input is estimated roughly as 3MJ per person-day.

**Source:** Based on Table 14.2 in Chinnappa and Silva 1977.
Food systems and needs

poor previous season, then peak work output may be impaired, reducing the potential for next year’s crop still further. Despite recent research into the nutrition and physiological work, most experimental measurements have sought to measure the steady-state behaviour of individuals and animals. Thus relatively little is known about responses to fluctuations in intake or work output, or about the body’s energy and nutrient storage mechanisms. Yet the latter may have a very much larger role than previously realised for key vitamins and minerals as well as for energy (Longhurst and Payne, 1979). Lacking knowledge of these, we cannot assess the risks of malnutrition for people living in highly seasonal environments.

Data on seasonal energy relationships in the context of rice cropping is available from the North Arcot district of Tamil Nadu state (India). Table 1.3 shows a breakdown of the time spent on various stages in the agricultural cycle, both for traditional (TV) and high yielding (HYV) varieties of rice (Chinnappa and Silva, 1977). The change to HYVs in this region increased yields to the point where a family of five people could theoretically meet its basic energy needs by cultivating only 0.5 ha. This estimate is based on a food energy output of 33,000 MJ per hectare annually. The ratio of energy output to input was then 40:1, which is slightly higher than before HYV rice was introduced.

It is clear, then, that a family which adopted HYVs did not require any additional labour to meet its own food requirements. But since yields were greater, these requirements could be met from less land. The remainder of the land formerly used could then produce a surplus for sale, but only if more labour was employed. In practice, most families adopting HYVs were those with the larger holdings, and they secured the extra labour by hiring workers from among the smaller cultivators and landless families. That particularly affected the employment of women for tasks occupying short, intensive seasons such as transplanting, weeding and harvesting (Table 1.3), which is significant in relation to a seasonal peak occurring locally in the birth rate (Chambers et al., 1981). At the time when they need to be working in the fields, many mothers have very young infants whom they should be breast-feeding. This can mean that feeds
are hurried, or badly spaced, and babies do not get enough (Devkota, 1981; Rickleton, 1981).

Not only do work patterns and birth rates commonly vary markedly with season, but so do infectious diseases. When seasonal peaks of infection coincide with times of food shortage and hard work, the consequences of malnutrition may be compounded. The greatest regular seasonal impact on rural society is often due to infections and parasites (Bradley, 1981), and these have strong interactions with nutrition.

Clearly, disease can be both a cause and a result of poverty. It affects the efficiency of work, and that is one of several reasons why the previous discussion of the minimum energy inputs needed to feed a family from a rice crop is a considerable simplification. In practice, the family’s survival would depend on exceeding these levels, so that there is a margin to allow for times when individuals are not working because of illness, as well as to allow for grain lost in store (5–10 per cent) or retained for seed. Furthermore, although the rice could supply all the energy and protein needs of the family, it would not fully supply vitamin and mineral needs. The family would thus have to invest more labour either in farm production of vegetables and other foods, or in paid employment, or in an increased production of rice for sale and exchange.

Very often, the levels of labour input referred to earlier would need to be increased by up to 50 per cent to cover the needs for exchange purposes, and to provide an insurance against poor harvests and crop levels. This insurance investment would depend upon the level of ecological variability of the region. In an extremely variable climate such as that of Burkina Faso, the traditional practice before 1920 was to aim for a level of stocks after harvest equivalent to 2–3 years’ grain consumption (George, 1980). However, the ability to make any insurance clearly depends on the labour and land resources available. In South Asia the marginal farm family with land restricted to less than their subsistence production needs will be in a precarious situation with regard to bad years and the landless even more so.
Family development

Seasonal changes in food supply must be studied in relation to the longer-term cycle of the family's demographic expansion, as children are born and grow up. During the first year or two of marriage, both parents are usually able to contribute in labour or other economic activity, particularly if the timing of pregnancy is such that the women can still work during the time-intensive part of the production cycle. Earning or production capacity will then be high in relation to the number of family members to be supported, and the economic dependency ratio is low.

Things may become more difficult as the number of children increases and if and when they are at school. Later, as the children take on more and more work, the economic burden carried by each working member of the family eases. Food energy needs in a family and the number of workers necessary to support that family are thus constantly changing over time.

Young children require relatively large amounts of dietary energy. A one-year-old child is one-fifth the weight of an adult, but his/her energy intake will be about half the adult level. Somehow the young child has to take in a relatively large amount of food. Much depends on the frequency with which a child is fed and on the amounts of milk she/he is given. Rutishauser (1974), working in Uganda, found that the factors associated with a good energy intake in children under two years old were:

1. breast-feeding continued while other foods were introduced
2. three or more non-breast feeds per day
3. 'good appetite', i.e. absence of infection.

It is of critical importance that the mother or whoever cares for a child should have sufficient time in the working day to help that child to feed, and in some cases, to prepare special items for him/her, because even though the family diet may have a good nutrient density, certain nutrient-rich items may be too spicy or hard to handle. The high growth rates and high relative energy needs of young children require frequent concentrated feeds, yet the lifestyle of many poor families makes this extremely difficult to achieve, especially at seasons when work is highly time-intensive (Wheeler, 1982).
We have already noted that adult agricultural workers sometimes lose weight during peak labour seasons and then regain it at times of year when there is more food available and less work. This fluctuation may be regarded as a satisfactory adaptation to a changing environment. However, if pregnant and lactating women suffer energy deficits during periods of hard physical work, their offspring will be smaller and more vulnerable (Paul et al., 1979). Evidence that Asian women’s energy status does fluctuate seasonally is provided by the observations of Chowdhury et al. (1981) in Bangladesh. There, the women of landless families tend to lose weight during the August–October period, when the highest labour demands for rice cultivation are just over, and the price of rice is highest. Should these women be pregnant or lactating at that season, the risk of malnutrition to both mother and child is increased.

Illness may temporarily alter nutrient requirements. Gastrointestinal diseases often lead to malabsorption of food, and many illnesses lead to tissue breakdown or blood loss to a varying degree. During the acute phase of an illness, nutrient utilisation

<table>
<thead>
<tr>
<th>Table 1.4 Food energy needs and labour available at three stages in the development of a family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food energy needs</td>
</tr>
<tr>
<td>MJ/year</td>
</tr>
<tr>
<td>Woman and man, 1 child under 2 years</td>
</tr>
<tr>
<td>Woman and man, 1 child under 2, 1 child between 2 &amp; 3, 1 child between 4 &amp; 5</td>
</tr>
<tr>
<td>Woman and man, 1 child under 5, 1 child between 8 &amp; 10*, 1 child between 10 &amp; 12*, 1 child between 12 &amp; 15**</td>
</tr>
</tbody>
</table>

Notes: * assumed equivalent to 0.5 of an economically active man; ** assumed equivalent to 0.8 of an economically active man.
falls so there is need for some increment during recovery. Clearly, this is a more serious matter for children than for adults; they need nutrients and energy for growth, and also their body nutrient reserves are small. This may be seen particularly in children with acute fevers or gastro-enteritis, who can become wasted and also dehydrated very fast, unless there is a determined effort to keep their fluid and food intake as high as possible (Mata, 1977; Briscoe, 1979).

For a great variety of reasons, then, human nutritional needs vary markedly throughout life. There is a steady fall in necessary intake in proportion to body weight until adulthood, after which the appropriate level of intake depends greatly on work and activity, and on physiological stresses, of which the most important for women is pregnancy.

Human requirements for food are not constant, but vary with the development of family groups as much as for individuals. Table 1.4 presents typical figures for a particular family at three stages in its development, and shows how there may be a critical period when the children are all young. At this stage, energy needs in relation to the labour available to meet them peak sharply. During this period, there is a maximum likelihood of malnutrition occurring, particularly at the most intensive stages of the seasonal cycle. Thus the focus of many nutrition programmes on the problems of young children makes sense not only because of the vulnerability of the children themselves, but also because of the vulnerability of the family group as a whole while the children are young.

To understand the prospects of the family group in more detail, however, we need to look beyond the children and enquire whether the family owns and cultivates its own land, and whether it is able to hire farm workers at especially busy times of year, since that is an important way of dealing with peak energy demands. Families with little or no land of their own will often be in more critical situations. Most difficult of all are the seasonal problems of families with small plots of their own, but who are also partly dependent on paid work. For them, the best opportunities for farm employment are likely to coincide with the heaviest demands of their own crops.
Limits to Measurement

Any investigation of the problems faced by such people should also take account of agricultural developments which may modify the magnitude and timing of seasonal effects, crop varieties and irrigation.

All our examples so far have been of rural agricultural households, but the principles could be applied to other groups such as urban unskilled labouring families, plantation workers, pastoralists, fishing families, and so on. Investigation of social or economic differences, of the effects of technical change, or seasonal constraints, and the problems of family development, entails classifying families by land ownership and tenure, by dependence on markets, and by major sources of income. This would be an example of what is referred to later (Chapter 6) as a ‘functional classification’ of the population being studied. Examining the prevalence rates for malnutrition season by season for each of the groups identified, enables us to study malnutrition on a comparative basis. Because of the importance of this approach, we shall repeatedly return to such questions as land tenure and cropping patterns. First, though, it is necessary to consider certain other nutritional concepts, and these are the subject for the next two chapters.
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