RELEVANCE OF RUMINANTS IN UPLAND MIXED-FARMING SYSTEMS IN EAST JAVA, INDONESIA

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In Indonesia, upland agriculture is associated with resource-poor farmers, land degradation, and low agricultural production. The common premise is that cattle productivity in upland areas is low and that this is mainly caused by a shortage of feed. The area chosen to carry out this study on the relevance of ruminants for upland mixed farming systems was the limestone area, a marginal upland area, in the southern part of Malang regency in East Java. The data collection was done within the framework of an interdisciplinary agricultural research training project. Two villages were selected as research sites because of their differences in land use and soil characteristics; land use dominated by sugarcane and annual crops vs land use where agroforestry is becoming increasingly important. Cattle are by far the most important livestock in the limestone area. Farmers aim at both physical production (progeny, increase in body weight, manure, draught power) and intangible benefits. The intangible benefits comprise the capital embodied in animals kept and the possibility of disposing of animals as and when required: insurance and finance. If the intangible benefits are counted in, farmers arrive at a daily return to labour from livestock similar to the ongoing daily wages in the agricultural sector. Systems for sharing ruminants enable the available labour and capital to be better used and distribute wealth more evenly in the village, and play a major role in replenishing herds after periods of severe drought. The use of cattle for land cultivation is related to the land use system. Land use also has important consequences for the feed resource base. Livestock keepers obtain a large proportion of feeds from communal areas and from crop fields operated by other farmers. In both villages the feeding system and herd size are well adapted to the available resources. Simulation proved to be a useful tool for understanding the feeding practices and the evaluation of proposed new technologies. Biological production can only be increased by increasing the amounts of high quality feeds. Overall, by keeping ruminants farmers efficiently allocate their resources i.e. labour and capital according to their household objectives. The objectives in research and development programmes should be set in relation to all benefits of livestock keeping. The interdisciplinary research approach has given insight into the versatility of livestock in supporting human welfare.

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PROPOSITIONS

1. In contrast to crop production studies, any investigation of the ruminant production aspects of a farm system cannot limit itself to the confines of the farm household boundary.
This thesis.

2. The starting point of all ruminant feeding strategies should be to analyze both the feed resource base and the objectives of the production system.
This thesis.

3. Any future strategies for the use of low quality roughages to enhance livestock production, must be based on the questions of when, how, and to what extent, the roughage can be used.

4. The manifold goals of cattle keeping make it difficult to introduce technologies which only aim to increase biological production.
This thesis.

5. It is a common misconception to call the cattle and buffaloes of South-East Asia draught animals. Actually, they are draught-capable.
Perkins, J. M. and Semali, A. 1989. Economic aspects of draught animal management in Subang, Indonesia. In: Draught Animals in Rural Development (D. Hoffman, J. Nari, R.J. Petherham, editors). ACIAR Proceedings No. 27, Canberra, 295-299.

6. As a result of economic pressures and colonial policies of exploiting crop and livestock products, formal education and research in developing countries has been strongly influenced by western scientific thought. Consequently, it bears the same characteristics of the physical and biological scientific tradition, as well as the focus on commodities.

7. Farmers do not think in terms of the adoption or non-adoption of a certain practice as scientists do, but instead select elements of technological complexes to suit their constantly changing circumstances.
Chambers, R., Pacey, A. and Thrupp, L.A. 1989. Farmer first: farmer innovation and agricultural research. Intermediate Technology Publications, London.

8. The improvement of crop and livestock production is essentially a biological process, which is not always compatible with an improvement in farmers' incomes.

9. The brains of farmers and scientists are almost identical.

Ifar S.
Relevance of ruminants in upland mixed-farming systems in East Java, Indonesia.
Wageningen, September 9, 1996

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CONTENTS Page

INTRODUCTION 1

Dry land mixed-farming systems are typical in most upland areas of the island of Java in Indonesia. Many of the smallholder households keep ruminants (cattle, sheep and goats). This study, which was conducted within the framework of the INterdisciplinary agricultural RESearch training (INRES) project (an on-the-job research training project in Farming Systems Analysis for staff from Brawijaya University, Malang, Indonesia), aims to improve knowledge and understanding of the relevance of ruminants for farmers in marginal uplands.

1.1. Upland agriculture

1.1.1. Topography of Java

Java lies approximately between 105° and 115° longitude, 5° and 10° south latitude. Its long axis runs west - east. A chain of mountains of more than 2000 m height extends along the whole length of the island. These contribute to the fertility of much of the land through their volcanic ash and formation of alluvial soils, and are the source of springs that run down the slopes before being routed into rivers flowing to the coast. The most fertile land is found on the mountain slopes, valley floors and river floodplains. This land is continually enriched with accessions of sediments containing nutrients and organic matter from eroded topsoils higher in the mountains.

Many hill ranges of non-volcanic origin also traverse Java. Chains of hills, in many places reaching heights of 300 to 500 m above sea level (a.s.l.) and sometimes much higher, extend along the southern coast of the island. These were mainly formed by uplift during the Miocene era and have since been covered by volcanic material. As long ago as 1817, Raffles reported that the soils on these Kendeng hills, were poorer than those in the river valleys. Even though the soils are considered to be poor, they are not unproductive if sufficient water is available.

1.1.2. Development of upland agriculture

The population density in the lowland fertile areas of Java has been high since the early 18th century. These alluvial basins with potential for irrigation were (and still are) mainly used for paddy. Later, in the 19^{th} century, as the population pressure on the lowlands increased and agricultural land became scarce, people began to move to the upland areas. This led to a considerable increase in the upland area under agriculture, which continued in the 20th century (from 0.6×10^6 ha in 1883 to 6.1×10^6 ha in 1989). This increase surpasses the increase in lowland paddy areas. The ratio of lowland paddy to upland farming area was 2.9 in 1883 and 0.5 in 1989 (Palte, 1989; Manuwoto, 1991). According to government statistics, the upland farming area in 1989 accounted for 64% of Java's agricultural land (BPS, 1989).

Kepas (1985) classified the upland dry land farming area in Java into three zones: limestone area, middle (500 to 1000 m a.s.l.) and upper (over 1000 m) slopes of volcanic areas. The limestone area includes the Kendeng chain of hills along the southern coast. Here farmers mainly cultivate maize and cassava for subsistence. In some parts sugarcane has been introduced. The middle and upper volcanic zones are mainly used for horticulture. In all three zones, a great variety of crops (annuals and perennials) are grown in close association and combinations varying with location. The middle and upper volcanic zones are endowed with deeper fertile soils and hence farmers here are more prosperous than those in the limestone zone. The upper slopes are less favourable because in many parts the topsoil has been eroded, leaving many farmers with heavy clay subsoils or limestone bedrock.

The upland areas are marginal to the economy of Java. This is why there is increasing interest in developing their potential. Enhancing their agricultural production will provide food for the ever-growing population. Furthermore, they have large economic and biophysical effects on lowland agro-ecosystems. Nearly all upland agro-ecosystems in Java are in the upper river catchments. Poor landuse management here (deforestation, absence of proper terraces on agricultural plots) results in severe soil erosion which has detrimental effects outside the area, such as sedimentation in reservoirs, the silting up of middle and lower river courses, floods, decreasing river debits and valuable topsoil being washed into the sea. The detrimental effects within the upland areas are soil degradation, low crop yields and low farmers' incomes. Consequently, most farm households in the upland areas live below the Indonesian poverty line (Kepas, 1985; Baharsyah, 1991).

Past efforts on agricultural development in Java have mostly concentrated on lowland rice production. Maintaining and improving the productivity of resources in upland areas has been a priority since the 1980s, when the country became self-sufficient in rice production (Bashaasha *et al.*, 1993). So far, the upland zone has not benefited from an equal share of attention from government development programmes.

From 1966 to 1980, reforestation on both private and state-owned lands was the only upland-based development activity. This, however, has been beset with many difficulties, as the participation and support of local communities was relatively low (Kepas, 1985; Soegijoko, 1993). In 1985, the Upland Agriculture and Conservation

Project (UACP) was established to improve agricultural production and to reduce erosion in two major watersheds in Java i.e. Jratunseluna in Central Java and Brantas in East Java. Selected farmers were subsidized for two years to implement improved cropping patterns and new crop varieties, to use inorganic fertilizers and insecticides and to construct terraces. The UACPs programmes included training for farmers, extensionists and project staff in land conservation techniques. When the subsidies to farmers stopped, however, the use of new cropping technologies and terracing gradually decreased because the farmers could not afford them (Gunardi and Saragih, 1993). Thus, the farmers' low income prevents them from investing in technologies to preserve their natural resource base. This results in further land degradation and a vicious circle of poverty develops.

The agro-ecological characteristics of the upland area are far more complex and diverse than those of the lowland paddy area. Agricultural land differs from site to site in response to differences in topography, soil types, soil fertility and agro-climatic conditions. This results in varying cropping practices, landuse management and production potential. Socio-economic conditions also vary. This is partly because of the differences in agro-ecological properties and partly because of the differences in distance and ease of access to large urban areas, which influence the availability of off-farm employment and the ability of people to commute to such employment. There are also differences in the labour requirements of individual enterprises and thus in their ability to employ people. Another related factor is the access to markets, which may determine profitability and the number of people that can be supported (Birowo and Hansen, 1981; Montgomery, 1981; White, 1981).

In the lowlands, a striking increase in rice production can be achieved by a single new variety or pesticide recommendation, but it appears to be difficult to formulate a simple, powerful recommendation applicable to a wide range of upland dry land farming situations, because the cropping system is so diverse. Thus, the successful experiences and technologies used to boost the lowland rice production cannot easily be implemented in the upland dry land farming areas. The search for suitable methods for maintaining and improving the productivity of resources in upland areas in Java is still in its infancy and needs further investigation. This is indicated by Manuwoto (1991) from the National Institute of Planning and Development (Bappenas) of Indonesia, whose policy statement can be summarized as follows:

> "*The utilization of upland areas is one of the alternatives for both agriculture and non-agriculture use. The problem in utilization of uplands is that knowledge of the characteristics of upland agriculture as one of the variables of the regional economy is very limited*".

1.1.3. Ruminants in upland areas

Ruminant production sub-systems cannot be separated from the overall issues involved in upland development as these are important for crop production and farm households' economy. Palte (1989) stated that the systems of ruminant production in the upland areas in Java have developed in response to demographic pressures on the upland areas and the need for farmers to maintain soil fertility. In the earlier stages of upland agriculture, shifting cultivation was practised. At that stage ruminants grazed freely on fallow lands. When the population in the area increased, this form of extensive agriculture, requiring long fallow periods, became untenable, so shifting cultivation was replaced by permanent cultivation. Consequently, ruminant husbandry changed from grazing towards cut-and-carry feeding, in which the animals are penned throughout the year. This method also allows farmers to collect and use the animal manure to fertilize permanently cultivated land. The farmers feed the ruminants grasses, weeds, tree leaves and crop residues. These forages are collected from various sources available in the area including e.g. road verges, river banks and cropping lands (Palte, 1989; Nibbering, 1991).

Apart from producing manure, ruminants are also kept by farmers to obtain cash income when needed e.g. to finance taxes, school fees, social obligations (e.g. marriages, funerals) or purchase of food in times of shortage before the next harvest (Palte, 1989; Edmundson and Edmundson, 1983; Nibbering, 1991).

Animal draught power for land cultivation was important during the period when extensive agriculture on more or less level lands was practised (i.e. until the beginning of the 20th century). As agriculture intensified and sloping fields became more prevalent, field preparation had to be carried out more carefully and the plough was gradually replaced by the hoe. Hoeing can be done more carefully than ploughing, both on level and sloped lands (Palte, 1989). Palte (1978) reported that famines in the 1960s due to abnormal weather also contributed to the change to hoeing.

Since the 1970s, dairy cattle in upland volcanic zones have received attention from the national agriculture development programme. This programme aims to increase farmers' income, fulfil the increasing demand for milk and to reduce the use of foreign exchange for milk importation. Overall, however, dairying is only of minor importance in the farming systems in Java. In East Java, for example, there were 93 769 dairy cattle in 1990 compared with 3 005 059 non-dairy cattle, 987 882 sheep and 2 109 310 goats (Rasman, 1991). The non-dairy cattle and other ruminants are spread throughout the rural areas, including the limestone uplands. However, much more research has been done on dairy cattle than on non-dairy cattle. One of the conclusions of the fourth agro-ecosystem workshop sponsored by the Indonesian Research Group on Agro-ecosystems (Kepas, 1985) was:

"Research into the opportunities for, and constraints to, improving the productivity of animal husbandry in Java's upland villages also seems warranted. This is particularly significant for the dry uplands of eastern Java where -- because of the poorer potential for dry land garden intensification -- the role of animals in the farming system is very important....especially on the limestone soil areas...".

1.2. INRES Project

1.2.1. Background

INRES (1989 - 1994) started as a cooperative programme between Brawijaya University in Indonesia, Wageningen Agricultural University and Leiden University in the Netherlands, in response to the fact that farms in East Java are mixed, incorporating a large variety of crops and animals. If the ultimate aim of agricultural research is improving the well-being of farming households, it is necessary to study the performance of the farm as a whole. Research on the development of a single farm component may overlook constraints imposed by other components or competition with other components, and may result in a net decrease in overall farm productivity. Consequently, the role of the various components which constitute a farm and their interrelationships should be understood; this means involving various disciplines in an interactive form of research (Tim INRES, 1992).

The INRES staff included seven staff members from Brawijaya University and two from Wageningen Agricultural University. They formed the so-called nucleus staff in the project, representing the disciplines agronomy, soil science, animal production, development economics and sociology. Seven of the nine nucleus staff members were PhD candidates who based their work on their contribution to the interdisciplinary teamwork. The author of this thesis represents the animal production discipline. In addition to the nucleus staff, other faculty members of Brawijaya University worked with INRES part-time. The various disciplines in INRES aimed to work as a team to construct scenarios for the development of farming systems in the limestone area of South Malang.

1.2.2. Research philosophy

It is generally agreed that prior to developing target scenarios, constraints that limit the performance of the present systems of farming need to be well defined. A specific approach to agricultural research and development known as Farming Systems Research and Development (FSR&D) has been developed for this purpose (Shaner *et al.*, 1982; Sands, 1986). The initial and crucial stage of the FSR&D is the Farming Systems Analysis (FSA), i.e. the understanding of the structure and functions of the existing farming systems, the analysis of constraints to agricultural production at farm level and ways to translate this understanding into adaptive research programmes (Fresco *et al.*, 1990).

FSA, however, has been subjected to criticisms, e.g. that it is too qualitative (Stroosnijder and van Rheenen, 1993). This makes it difficult for policy makers, end-users and scientists to accurately assess the problems in a region and to determine in which order these have to be addressed. Often, several clients will be interested in the development of the agricultural sector, e.g. farmers operating land holdings of various sizes, the commercial sector, and policy makers. The goals of these different clients may differ and even conflict. This leads to a discussion of which goal or compromise of goals would be best to pursue. Taking this criticism into account, INRES has attempted to develop a new approach to FSA, called quantified farming systems analysis (QFSA), which will enable the trade-off between goals to be computed (Stroosnijder *et al.*, 1994).

To arrive at realistic development scenarios, the role of components of the existing farming systems (the farmers and their families, land, annual and perennial crops, and animals) needs to be described. The analysis of bio-physical production comprises two stages. The first is to characterize crop and livestock production sub-systems separately. The role of perennials was analysed by the INRES agronomist (Sunaryo, 1996). The INRES soil scientist studied the role of annuals as part of the topic "The role of quantified land evaluation in FSA" (Widianto, 1996). Research geared toward elucidating the existing ruminant production systems is presented in this thesis. The second step of bio-physical production analysis includes modelling work that integrates the crop and livestock sub-systems. This is part of the topic "Quantifying the physical production potential of farming systems in the limestone area of East Java" (Efdé, 1996). The economists studied the allocation of resources by the farming households (Mustadjab *et al.*, 1992). Sociological studies concentrated on the decision making process in the farming households (Solichin, 1996). The results of the bio-physical and socio-economic analyses were integrated (using Interactive Multiple Goal Linear Programming, IMGLP), to explore options for development at farm level, as part of the topic "Farm household level optimal resource allocation" (van Rheenen, 1995).

1.2.3. Research programmes

The area chosen to carry out the INRES study was the limestone area in the southern part of Malang regency in East Java. This is one of the many upland areas in Java that are considered marginal by the policy makers and therefore a priority area for improvement. The rapid erosion in the area causes severe sedimentation in the Brantas river which flows north. It is feared that this will reduce the effective lifespan of the very costly water reservoir constructed in the river valley (Karangkates dam). Also, the local government of the Malang regency is committed to increase the income of farmers in this area, because at present their average income is 30% below that of farmers in the northern part of Malang (Anonymous, 1989[b], Ginting, 1993; Saragih *et al.*, 1993).

Two types of research were conducted in INRES: i.e. joint research and disciplinary research. The joint research efforts mainly aimed to construct databases from which data relevant to the work of each discipline could be retrieved. This work began with secondary data analysis from January to March 1989. It aimed at characterizing the study area in terms of agro-climatic, soil, land use and socio-economic conditions. It involved assembling and analysing maps of soil, topography and agro-climate (Kalikonto project, 1988) and statistics for the Malang Regency (Anonymous, 1989[a]). The main findings are described in Chapter 2.

The limestone area of South Malang comprises five districts i.e. Pagak, Kalipare, Donomulyo, Bantur and Gedangan, four of which were selected for a reconnaissance survey. That survey was done in July and August 1989. The objective was to describe existing farming systems and their problems through observations and interviews with farmers and key informants. In this survey, the villages of Sidodadi (Gedangan district), Pringgodani (Bantur district), Kedungsalam (Donomulyo district) and Putukrejo (Kalipare district) were visited (see Figure 1.1). The villages were nominated by the heads of the respective districts. Five per cent of the farm households were selected randomly (based on village records) in each village. A total of 183 farm households in the four villages were visited once, by two INRES staff members, one representing a technical discipline and one representing a socio-economic discipline. The respondents were asked about their problems in farming. Some quantitative data on farm households' assets (land, crops, animals, implements) were also recorded.

The villages of Putukrejo and Kedungsalam were chosen for further study. A total of 35 farmers (12 in Putukrejo and 23 in Kedungsalam) were selected to be studied in-depth. They were selected on the following criteria: (1) growing maize or cassava; (2) not growing sugarcane and/or wet rice; (3) farming between 0.33 and 0.66 ha of land; and (4) keeping at least one type of ruminant animal. In order to study in-depth

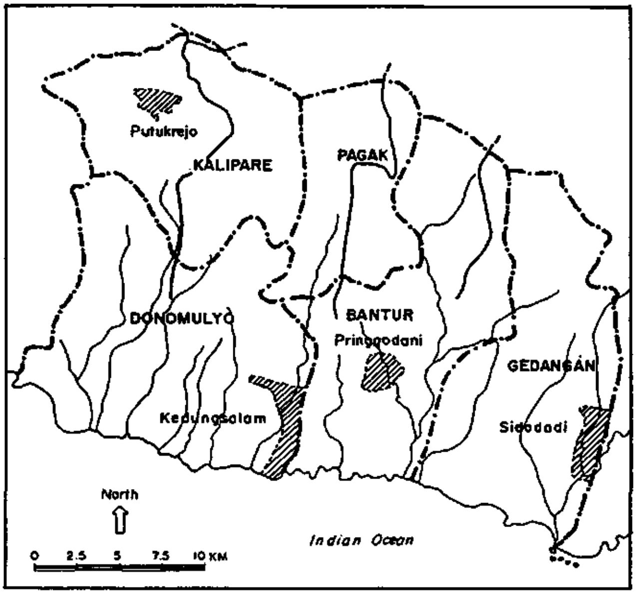

Figure 1.1. Districts (in capitals) in South Malang and the villages visited during the INRES's reconnaissance survey.

a number of ongoing technical and socio-economic processes in those 35 farms, an Intensive Farm Households Survey (IFHS) was conducted from October 1990 to March 1992. This survey yielded information on inputs and outputs of agriculture and non-agriculture activities per period of six days.

In addition to the above, a baseline survey, including 150 households in Putukrejo and 398 households in Kedungsalam, was carried out by the economic section of INRES from January to March 1992 to make an inventory of the household resource base (land, animals and family labour) and family consumption.

Details of the above joint research programmes are presented in the work mentioned in Section 1.2.2 or in this thesis in combination with the animal production research programmes.

1.3. Rationale and objectives of the study

Historical studies (Palte, 1989; Nibbering, 1991) have shown that there were adaptive changes in the management and use of ruminants during the development stages of upland areas in Java. These were influenced by the prevailing agro-ecological (topography, climate, land quality) and socio-economic (population pressure, cropping intensification, need of capital) factors. It is generally claimed that ruminants are kept to provide inputs for crop production and to obtain cash. However, the various roles of ruminants have usually only been described qualitatively.

The common premise is that ruminant production in upland areas is low (Kepas, 1985). Palte (1989) and Nibbering (1991) mentioned that shortage of feed limits the possibility of farmers increasing production. This implies that problems of ruminant production in the area could be similar to those in various small-scale mixed farming communities in South-East Asian countries, i.e. feed quality and seasonal availability. This is the most pervasive constraint limiting the number and productivity of ruminants in the region (de Boer, 1982; Moog, 1985; Atmadilaga, 1992; Udo *et al.*, 1992).

Low production, in terms of live weight, can indeed be linked to problems of low quantity and quality of feed. If production of meat is the only goal, benefits could be maximized if the amount of feed spent on maintenance were minimized. With all feeds of similar quality, this would be achieved by adjusting the number of animals to a level where all animals are fed *ad libitum* and all feeds are utilized. When feeds vary in quality, with some feeds not even meeting the maintenance requirements, and the farmers (or the animal) can select, it may well be that production is maximized if some of the feeds are left unutilized (Zemmelink, 1986[a,b,c]). The logic for this lies in the fact that when all feeds are used, the average quality of the ration may become so low that the advantage of having more animals is outweighed by the reduced production per animal. It could also be that farmers aim more at accumulation of assets, production of manure or draught power (Edmundson and Edmundson, 1983; Palte, 1989). Then, problems of low liveweight production become much less relevant. In other words, farmers accept low liveweight gain and aim at other benefits from livestock. This implies that the poorer quality feeds can also be utilized. This needs research that emphasizes the interactions between the role of ruminants and the feed resource base.

Various options for solving problems of low ruminant production and seasonal feed supply in the tropical regions have been considered and tested in the laboratory or in the field. They include the use of exotic forages, catalytic supplements or alkaline treatment of poor-quality crop residues (Shelton, 1980; Suryajantrong and Wilaipon, 1985; Doyle *et al.*, 1986; Moog, 1985; Preston and Leng, 1987; Schiere, 1995). However, experimental research on these technologies has had little impact on feeding practices and consequently on production at farm level in resource-poor agricultural production systems in the tropics. One premise about the poor adoption of new technologies is that past agricultural research focused more on increasing the crop and livestock production capacity than on adapting technologies to farmers' ecological and socio-economic production constraints (Fresco *et al.*, 1990). Fresco and Westphal (1988) argued that agro-climatic factors in a given zone are the primary determinants of an existing production system. They are relatively constant, predictable and can be influenced by farmers only to a limited degree. The diversity of production systems in a given zone arises from socio-economic factors in combination with the primary agro-ecological determinants. These factors include availability of on-farm labour and the aim of farming as related to changing family cycles or market opportunities. They are more dynamic than the agro-ecological factors. Failure to understand the significant diversity in socio-economic circumstances and the agro-ecological environments in which the resource-poor farmers operate has made broad-based technologies inappropriate (Norman *et al.*, 1982; Hart, 1982; Collinson, 1983). Mahadevan and Devendra (1985) showed that livestock production systems in a particular area are influenced more by socio-economic factors than by agro-ecological factors. This implies that it is not easy to introduce technological innovations in livestock production at the level of the smallholder. Ellis (1988) concludes that there is no quick technical fix to the problems of poor peasants independent of the social conditions of their livelihood. Farmers are doing the best they can do given their resources. This does not preclude that technical competence varies between farmers.

On the basis of the above rationale, the present research was conducted with the following objectives:

1. to identify and quantify the roles of ruminants in the farm household systems
2. to quantify the resource base and its utilization
3. to relate the various roles of ruminants in the farming systems to the feed resource base, with a view of understanding the overall system and identifying possible improvements.

The thesis follows the following general outline. After this introduction (Chapter 1), Chapter 2 gives a general agro-ecological and socio-economic description of the limestone area of South Malang. Secondary data and a reconnaissance survey served as a basis to select the research sites, Putukrejo and Kedungsalam, for detailed case studies. In the following three chapters the role of ruminants in the farming systems is described. Chapter 3 evaluates the social system of 'sharing', whereby resource-poor farmers can acquire the benefits of keeping animals. Chapter 4 describes the relevance of cattle for land cultivation in relation to land characteristics in Putukrejo and Kedungsalam. Chapter 5 quantifies the benefits of cattle for the farm household. It describes the value of physical production (live weight, draught power and manure) and intangible production (financing and insurance) of cattle, the returns of added value to labour or capital and the contribution to farmers' income. Thereafter, two chapters dealing with forage resources and utilization are presented. Chapter 6 gives detailed analyses of feed resources in Putukrejo and Kedungsalam and the way in which these resources are utilized. Data on seasonal forage availability both in quantitative and qualitative terms, are further analysed in Chapter 7, using a simulation programme, to arrive at quantitative estimates for the effects of selective utilization of feeds by farmers, monthly variation in optimum herd size and liveweight production and the optimum constant herd size. In addition, possible options for increasing physical production of ruminants are discussed. Chapter 8 links the socio-economic roles of ruminants in the farming systems with the feed resource base. This chapter discusses some opportunities and constraints for further improvement of cattle production. Finally it discusses the pros and cons of the interdisciplinary research methodology which formed the basis of the INRES project.

SETTING OF THE UPLAND LIMESTONE AREA OF SOUTH MALANG 2

This chapter provides a general agro-ecological and socio-economic description of the limestone area of South Malang (Figure 2.1) based on secondary data and the reconnaissance survey conducted by the INRES project. The research sites for the detailed case studies were selected on the basis of this information.

2.1. Location and orientation

The limestone area is situated approximately between longitude 112°08' to 112°48' east and between latitudes 08°00' to 08°30' south. It covers about 68 240 ha of land (Anonymous, 1989[b]). The area runs west-east, between the Brantas river in the north and Indian Ocean in the south. It is part of the Kendeng chain of mountains along the south coast of East and Central Java. The crest of the mountain range divides the area into two parallel zones (Figure 2.2): the northern slope draining into the Brantas river, and the southern slope draining into the Indian Ocean. The limestone is Miocene, overlain by more recent volcanic material.

2.2. Climate

The climate in the area is mainly determined by the tropical monsoon, which divides the year into two main seasons, i.e. dry and wet, with two short transitional periods in between. The wet season usually starts in October or November and ends somewhere between April and July. Records from the rainfall station in Pagak, over a period of 32 years, indicate that annual rainfall varies from 1130 mm to 2700 mm, with the number of rainy days ranging from 62 to 147. The mean annual rainfall is 1900 mm, falling on average in 100 rainy days, while the mean annual temperature is 24°C. In 30% of the years the area had a pronounced dry season lasting seven to nine months. Relative humidity varies from 80 to 90% (Widianto, 1996).

Figure 2.1. Setting of the limestone area of South Malang in East Java, Indonesia.

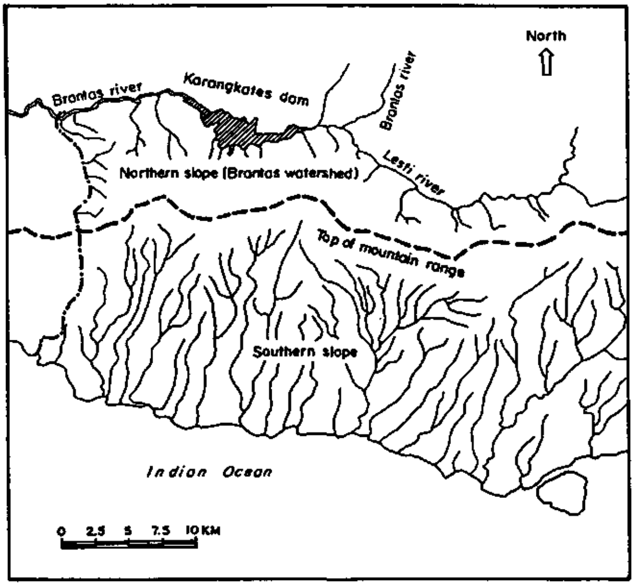

Figure 2.2. North and south divisions of the South Malang area.

2.3. Soil

The volcanic topsoil of many sloping areas has been washed away by surface runoff and deposited in the valleys. As a result there are steeply inclined and shallow soils (<25 cm depth) on slopes and ridges, and deep flat soils (>75 cm) in valley bottoms

Table 2.1. Type of land use and its occurrence in the South Malang limestone area.

Local name	Occurrence (%)	Description
Tegalan	49	Cultivated field which is neither irrigated nor bunded to retain rainwater
Sawah	7	Bunded fields for rice cultivation, either rainfed or irrigated
Pekarangan	16	Part of the house lot (plot on which household's dwelling is found) used for garden crops and fruits
Perkebunan	2	Areas planted with cash or industrial crops such as coconut, coffee and tea
Hutan negara	20	State-owned land designated for forestry
Lain-lain	6	Others; not specified

Source: Anonymous (1989[a])

and occasionally also on level plateaus. On the crest of the mountain range (450 to 550 m a.s.l.) there are villages with relatively flat land. Along the southern slope, the soil gradually becomes shallower. In many places in the south, soils are severely eroded so that the underlying limestone is exposed.

2.4. Land use types

Table 2.1 shows types of land use and their occurrence in the limestone area of South Malang as defined by Anonymous (1989[a]). Most of the area is used as *tegalan*. The crops grown on *tegalan* include maize, cassava, rice, soybean, peanut and sugarcane. Krisdiana and Laumans (1988) reported that intercropping of cassava and maize was most prevalent (on 54% of *tegalan*). Monocropping of cassava was negligible. Eight percent of *tegalan* was used for monocrops of maize. Sugarcane occupied 7% of *tegalan*. The rest of *tegalan* was used for intercropping maize with cassava, soybean, peanut or rice.

The secondary data on perennials available per district cover industrial crops only. These can be found in the *pekarangan* and *perkebunan* land use types. Of the total area used for perennials (12 798 ha), 58% is used to grow coconuts. The remainder is used for kapok (28%), coffee (10%), cloves (3%) and vanilla (1%).

The reconnaissance survey revealed that the pattern of agriculture changes gradually from north to south from annual crops to mixed cropping of annuals and perennials (Figure 2.3). The main cropping system is cassava intercropped with maize.

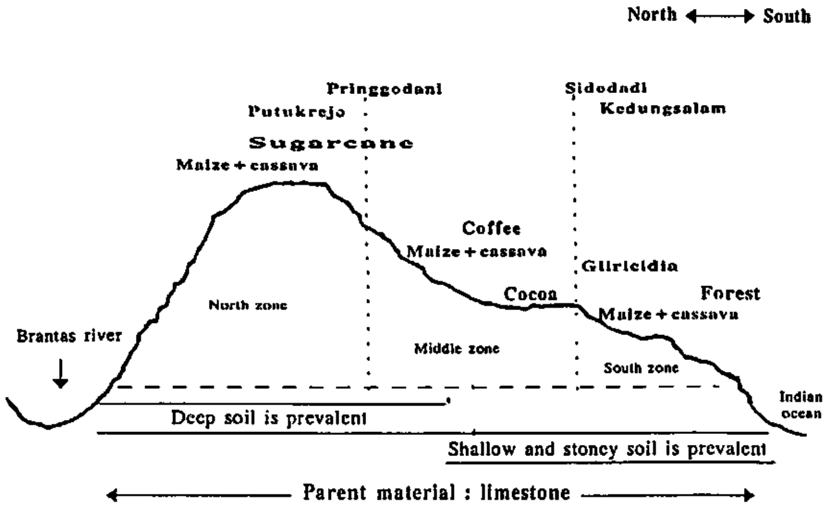

Figure 2.3. North-south transect of the limestone area of South Malang.

In the south, more gliricidia (*Gliricidia sepium*) is planted than in the north. Also more coconut was found in the south. Industrial perennial crops such as coffee or cocoa are more prevalent in the middle zone. Along the southern coast there is a belt of natural forest. Sugarcane is grown mainly on the flatter areas in the northern part.

Soil conditions change gradually from north to south. Deep soils are prevalent in the north. Shallow soils become more prevalent in the south. In the south, bare limestone with scattered shallow soils is found. This type of land provides the people in the southern area with the raw materials for producing lime through the process of burning limestone in a kiln. Lime burning is most prevalent in the southern zone.

2.5. Human population

The population density in 1987 was 395 km^{-2} (Anonymous, 1989[a]). The district of Pagak was the most densely populated (493 km^{-2}) and the least dense was the Gedangan district (314 km^{-2}). These density figures are far below those for other parts of the Malang regency (1161 km^{-2}) or for Java in 1990, i.e. 799 km^{-2} (Kepas, 1985).

The large variation in human population density in the Malang regency represents a common phenomenon in Java. Perkins *et al.* (1986) e.g. found a range of 100-2000 people km^{-2}, depending on resources available and on the distance and ease of access to large urban areas, which influences the availability of off-farm employment and the access to markets.

Table 2.2. Distribution of farmers (in %) over different farm size classes in each village studied.

Village	Farm size class (ha)					
	<0.10	0.10-0.32	0.33-0.66	0.67-1.50	1.51-3.00	>3.00
Pringgodani	4	41	23	21	7	4
Kedungsalam	2	16	27	35	14	6
Putukrejo	13	13	25	38	4	8
Sidodadi	8	21	21	34	11	5
Average	7	23	24	32	9	6

Source: INRES nucleus team (1989)

2.6. Ruminant density

The density of cattle in South Malang is 0.48 head ha^{-1} which is slightly above the overall mean for the Malang regency (0.43 head ha^{-1}). However, the number of cattle per household in South Malang (0.50) is the highest in the regency. The overall number of cattle per household in the Malang regency is 0.29. Goats and sheep are also present in the limestone area of South Malang. In 1989 there were respectively 0.25 goats and 0.22 sheep per ha (INRES nucleus team, 1989).

2.7. Farmers' activities

The size of farms in the four villages ranges from 0 to 16 ha, suggesting the existence of landless as well as 'large' farmers. The distribution of farmers according to different farm size classes is shown in Table 2.2.

The activities of farmers can be grouped into annual and perennial crop cultivation, ruminant rearing, non-agriculture activities and off-farm activities. All farmers, except the landless, cultivate local varieties of maize and cassava for home consumption and sale. The highest proportion of farmers who mentioned growing maize (78%) and cassava (71%) only for home consumption was in the farm size category 0.33-0.66 ha. Sugarcane was mainly cultivated by farmers with 0.67-1.50 ha or more in Pringgodani and Putukrejo. A mixture of perennials, including fruit trees (jackfruit, coconut, mango), timber trees (sengon and teak), industrial tree crops (coffee) as well as firewood trees (gliricidia, *Calliandra sp.* and *Acacia sp.*) is grown by farmers on their *pekarangan*.

The inputs used for the annual crops include labour (mainly from the own household), purchased inorganic fertilizers such as urea and triple superphosphate, farmyard manure (FYM) and draught animal power (DAP). Planting materials, i.e. maize seeds or cassava cuttings, were derived within the farm from the previous planting. Nearly all ruminant keepers mentioned that the response of crops to the application of inorganic fertilizers is not satisfactory, unless FYM is also used. Draught animals or hand labour was used to prepare agricultural land. About 83% of respondents in Pringgodani, Kedungsalam and Putukrejo used cattle to prepare land, compared with less than 50% in Sidodadi. Many farmers in Sidodadi stated that their land is too stony to be ploughed. It can only be prepared using a hoe or *ganco* (hooked stick).

On average, 45% of the respondents were engaged in non-agriculture activities and 59% in off-farm activities to supplement their income. The non-agriculture activities are activities other than farming done on the farm, e.g. making mattresses, pottery and bamboo utensils. The off-farm activities are of two types; those related to agriculture such as hoeing, weeding or ploughing using cattle on other farms and those that have no relation with agriculture, such as carpenting, driving of public transport mini-buses or artisanal work. In each village there was migration of both males and females (usually persons between 15 to 26 years of age) to the cities of Malang, Surabaya (the capital city of East Java), Jakarta (the capital city of Indonesia) and even to Saudi Arabia and Singapore. Those who went to the big cities in Indonesia commonly worked as house servant, *bakso*[1] sellers or artisans. Some of them regularly sent remittances home and others brought money when they visited their families (usually during the *lebaran*[2]).

Each of the activities can be regarded as a sub-system of the farm household systems. The household sub-system provides labour (including skills and knowledge) and cash to other sub-systems (cultivation of annual and perennial crops, non-agriculture on-farm activities, livestock keeping and off-farm activities) that contribute to food, income and assets for the livelihood of the farm household system.

2.8. Livestock in the limestone area

As mentioned earlier, a reconnaissance survey was conducted by the INRES team in four villages, covering 183 households. This section discusses the findings on

1) Soup with meat balls

2) Moslem festivity to celebrate the end of the fasting month

Table 2.3. Proportion of all respondents (%) rearing cattle, sheep and/or goats.

Village	n	Animal type						
		Cattle only	Cattle and sheep	Cattle and goats	Cattle, sheep and goats	Sheep only	Goats only	Total
Pringgodani	46	74	0	0	0	0	0	74
Kedungsalam	51	35	2	14	2	10	16	79
Putukrejo	48	52	10	2	0	4	4	72
Sidodadi	38	58	0	0	0	0	0	58
Total	183	55	3	4	1	4	5	72

livestock.

The ruminant types kept by farmers include grade-Ongole cattle, fat-tailed sheep and grade-Etawah goats. Grade-Ongole cattle are a cross between Javanese cattle (probably a cross between Zebu and Balinese cattle - Mason, 1969) and Ongole cattle imported in the first decades of this century (Tillman, 1981) from Madras (India). Huitema (1982) reported that the grade-Ongole cattle have the characteristics of Ongole cattle and are larger than the original Javanese cattle. That author also stated that the grade-Etawah goats result from a crossbreeding programme that started in the 1930s to improve local Javanese goats with Jamnapari goats imported from Uttar Pradesh (India). The fat-tailed sheep is an indigenous breed from Madura and East Java.

Most (72%) of the farmers keep ruminants (Table 2.3). The most prevalent ruminants are cattle (kept by 63% of the respondents), followed by goats and sheep. The lowest proportion of farmers keeping ruminants was in Sidodadi. In this village and in Pringgodani, no small ruminants were found. Farmers rearing cattle only are most common in Pringgodani. Rearing of small ruminants in combination with cattle is most common in Kedungsalam. Most of the farmers keeping goats were also in Kedungsalam.

Ruminants are kept not only for their direct functions in the farming systems (providing manure and draught power) but also to accumulate assets obtained from their growth and progeny. Cattle are preferred to achieve these goals because apart from being a source of manure and draught power they bring the most cash when sold. When farmers were asked when and why they sell ruminants, none of them mentioned maximizing profit or income. Their answers always concentrated on the need for money (e.g. to build or renovate a house, to have a wedding feast, to rent new land or to cover medical expenses). Ruminants can be sold in the livestock market or through middlemen living in the village. The selling price is determined by the physical appearance and live weight of the animal.

Farmers who do not keep ruminants generally said that they did not have labour in the household to collect feed or lacked capital to buy animals. However, it was found that ruminants can be obtained through an animal-sharing system. Farmers in Putukrejo said that cattle for sharing could easily be obtained from the better-off farmers in the village. In Kedungsalam, however, farmers mentioned difficulties in obtaining shared animals because wealthy villagers preferred to invest in the limestone burning industry.

The cut-and-carry feeding is practised in all villages. The types of forage used include native grass, cassava tops, maize leaves, rice straw, sugarcane tops and gliricidia leaves. These are collected from various sources in the area including roadsides, riversides, forest edges and fields. This enables both small and larger farms to keep cattle. There was no statistically significant correlation between farm size and number of cattle reared per farm, although there tended to be fewer animals on the smallest farms (<0.33 ha). Concentrates are not used because they are considered expensive. Rice bran is produced by the local rice milling factory but is sold to the poultry industry outside the limestone area. Farmers mentioned that it is difficult to provide feed during the dry season. In periods of feed scarcity, rice straw may be transported from the lowland area as far as 20 to 100 km away, where irrigated rice farming is dominant. Usually a group of four to six farmers hire a truck to transport the straw to the village. In Putukrejo, sugarcane is usually harvested during the dry season, between June and October-November. As a result, feed supply in Putukrejo is less dependent on season than in Kedungsalam.

Poultry are nearly always of the traditional type (*ayam kampung*). They are kept in small flocks, ranging from 2 to 10 birds, by nearly all households. They are kept as scavengers, requiring little or no inputs in terms of feed and labour, and giving a low output in the form of eggs and meat. They also serve as a source of cash income and may play a role in the household economy when a small amount of cash is needed e.g. to pay village taxes. The amount of cash obtained from selling a bird is reportedly Rp. 2000 - 4000 per bird, equivalent to approximately twice the daily wage for labourers in the area.

2.9. Research sites

The villages of Putukrejo and Kedungsalam were selected as research sites mainly on the basis of their differences in landform and soil characteristics. Putukrejo is situated in a rather flat area on the crest of the mountain range somewhat extended to the Brantas catchment area. Its elevation ranges from 450 to 550 m a.s.l. Although also affected by erosion, not all the topsoil has been removed, except on steep slopes. Sugarcane is grown extensively on the flatter areas. Wet rice is cultivated on the valley bottoms. There is hardly any forest. The second village, Kedungsalam, is situated on the southern slope, extending from the highest part of the area at about 400 m a.s.l. in the north to the coast in the south. The village is located on north-south crests and ridges, some of which are gentle, but most of which are steep. Agroforestry systems dominate the land use. The southern part of the village still has some natural and productive forest. In both villages there are stony or gravelly soils which are not tillable nor suitable for annual crops. They are covered with native grasses and shrubs; locally these soils are called *bongkoran*. These areas can be used for perennials.

In general, there is much more erosion in Kedungsalam, with its cropping on slopes, than in Putukrejo. Hence, soils here are mostly shallow, whereas Putukrejo has a considerable area of flat and deep soils. Studies done by the INRES soil scientist indicate that the fertility status of the soils on agricultural land is characterized by low organic matter content in the topsoil: 0.9% with a coefficient of variation of 58%, so, there is a large variation between plots (Susilo, 1991).

The total areas of Putukrejo and Kedungsalam are 11 and 44 km^2 respectively (Anonymous, 1989[b]; Anonymous, 1989[c]). In 1989, there were 1012 households in Putukrejo and 2256 in Kedungsalam. The average family size was 4.1 in Putukrejo and 4.3 in Kedungsalam. This gives a population density of 379 persons km^{-2} in Putukrejo and 218 persons km^{-2} in Kedungsalam. In each village there has been out-migration. In 1990, 111 persons migrated from Putukrejo (Solichin, 1991) whereas 297 people migrated in 1989 from Kedungsalam (Van Helden; 1991). They went to the big cities in Java, other islands in Indonesia or abroad (Saudi Arabia, Singapore).

Putukrejo lies off the main road, but village roads and footpaths connect its various hamlets with the main road. An asphalted road running north-south crosses two hamlets in the centre of Kedungsalam. Other hamlets are connected to this main road by village roads and footpaths. In both villages the village roads and footpaths are mostly unpaved and during the wet season even four-wheel drive vehicles or motorcycles have extreme difficulty using them.

There is no market in Putukrejo. The nearest market, held every five days, is located in the adjacent village. Here transactions of crop products, chickens and small ruminants take place. This type of market is also present in the centre of Kedungsalam. In each village, small shops sell daily needs. Some of them purchase sun-dried cassava, maize and rice from the farmers. The nearest cattle market to both villages is in Donomulyo, approx. 15 km south-east of Putukrejo and 10 km north-east of Kedungsalam.

FARMERS' ACCESS TO CATTLE VIA SHARING 3

3.1. Introduction

Farmers consider that rearing ruminants, particularly cattle, is the best way to accumulate capital (Section 2.8). This is also true for other upland farming areas in Java (Edmundson and Edmundson, 1983; Palte, 1989; Nibbering, 1991). Farming households like to acquire cattle at an early stage of household development. However, most households lack the capital to do this. In Java, animal sharing agreements can enable resource-poor farmers to acquire the benefits of keeping animals (Sabrani and Knipscheer, 1982). This chapter evaluates the access of farming households in the INRES's research sites to cattle via sharing, and the division of benefits and responsibilities between owners and sharers.

3.2. Methods

In January 1991, 548 randomly selected farms (150 in Putukrejo and 398 in Kedungsalam) were surveyed to estimate the distribution of ruminants over the villages. The number of ruminants and ownership (owned or shared) were recorded per farm. In addition, the respondents were asked to rank the following reasons for keeping cattle: production of progeny, manure, weight gain, draught purposes and as a form of savings. Then, in March 1992, the same parameters were recorded again as part of an INRES household survey on 206 and 350 farms randomly selected in Putukrejo and Kedungsalam. To estimate the changes in cattle numbers between January 1991 and March 1992 the number of cattle recorded in the two surveys was extrapolated to the total number of households in the two villages.

From January to March 1991, 35 farmers were interviewed (12 in Putukrejo and 23 in Kedungsalam), to investigate various aspects related to ruminants, such as when and why the respondents decided to start keeping ruminants and how they acquired the animals. Case studies were done on the history of 12 of the 35 households, to collect detailed information on the decision making with regard to keeping livestock. Similarly, eight owners of large herds of cattle (> 100 animals) - five in Putukrejo and three in Kedungsalam - as well as village officials, were interviewed to obtain additional information on factors affecting the access of individual farmers to ruminants, especially cattle.

3.3. Results

3.3.1. Ownership and prevalence of ruminants

Cattle are the preferred ruminant because they give a higher income than goats and sheep. In Putukrejo and Kedungsalam goats were kept by only 19 and 30% of the households surveyed, respectively, and sheep by 20 and 9.5% of these households, respectively. Around 80% of these households kept small ruminants as owned animals only. More households in Kedungsalam keep goats because this village has larger resources of gliricidia than Putukrejo (the leaves of this tree are regarded as good feed for goats). In Kedungsalam, sheep are less popular, because farmers believe that to obtain satisfactory weight gain the sheep must be herded, and this is considered tedious. However, some farmers do not herd their sheep and accept a poorer performance.

Figure 3.1 shows the changes in cattle distribution and ownership in the two villages of Putukrejo and Kedungsalam between January 1991 and March 1992. In January 1991 the proportion of farms keeping cattle in the two villages was very similar (61-62%). By March 1992, however, the proportion was significantly ($P<0.05$) smaller in Putukrejo (52%) than in Kedungsalam (60%). Three types of livestock farms can be distinguished, i.e. farms keeping their own animals only, those keeping owned and shared animals, or those keeping shared animals only. Between January 1991 and March 1992, the proportion of farms keeping owned cattle decreased by 40% in Putukrejo and 12% in Kedungsalam and the proportion of farms keeping shared cattle increased by 53% in Putukrejo and 39% in Kedungsalam. Between January 1991 and March 1992, the estimated total number of cattle in each village decreased by about 10 per cent. The proportion of shared cattle increased from 37 to 56% in Putukrejo, and from 22 to 32% in Kedungsalam.

Herd size per cattle farm was the same in the two villages in January 1991, i.e. 1.9 animals. In March 1992 it was slightly higher in Putukrejo (2.0 animals) than in Kedungsalam (1.8 animals).

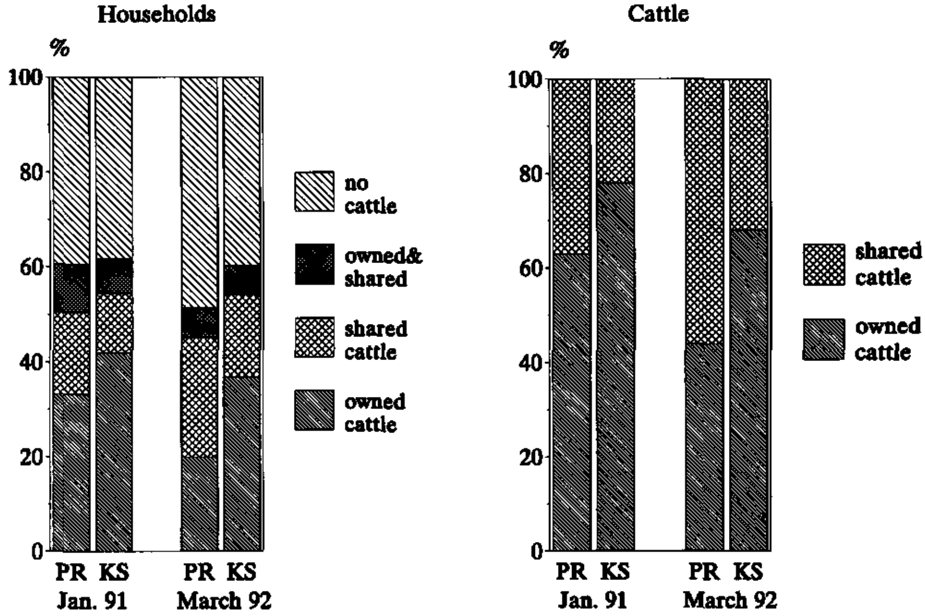

Figure 3.1. Proportion of households keeping cattle according to ownership and proportion of cattle according to ownership in Putukrejo (PR) and Kedungsalam (KS) in January 1991 and March 1992.

3.3.2. Aim of keeping cattle

Table 3.1 gives the farmers' ranking of the reasons for keeping cattle. Most farmers opt for the production of progeny and manure as their first objective in rearing cattle, followed by providing draught power and savings. Farmers referred to their cattle as a saving (*tabungan* in Javanese) that gives security. Animals as savings have a higher priority in Kedungsalam than in Putukrejo. Liveweight gain of individual animals is ranked lowest.

About half of the respondents in Kedungsalam did not rank the option of using animals for draught. This was influenced by several factors, including land quality (soil is often too shallow or stony to be ploughed) and the size of plots (these may be small and can be prepared within a few days, using the hoe). This village has a *sayan* custom of reciprocal help, i.e. the members of the community help each other, without payment, to prepare land, build houses and in other activities. Under this custom, those who receive help for land preparation will provide a meal for the helpers. If the helper also brings draught cattle, the farmer who receives the help will provide feed for the animals.

Table 3.1 shows that in each village, half the respondents accorded little priority to weight gain in their cattle keeping. The farmers have no intention of fattening cattle as is done in other villages by farmers of Madurese origin. Farmers in Putukrejo and Kedungsalam consider this to be too risky, because if the animal dies they loose the money and extra time spent on feed inputs. Nevertheless, they are concerned about the weight of their cattle because it determines the selling price.

3.3.3. Requirements for becoming a cattle sharer

From the owner's point of view, sharing out of animals means selecting between prospective sharers, because a considerable financial risk is involved. If the animal dies while in the hands of a sharer, the owner receives no compensation from the sharer. Owners only give their animals for sharing if they are confident that the animals will be taken care of properly. Owners evaluate applicant sharers as follows: (1) the household concerned should have some prior experience with keeping animals and (2) should be able to collect fodder continuously; (3) the applicant should not be a commuter or person who works and stays outside the village for several months a year, and (4) should not be single; and (5) if the applicant has children, these should preferably be grown up or at least belong to the work force, which according to local standards includes persons from 10 years onwards.

It is not always easy for owners to evaluate applicants or monitor the performance of sharers. Therefore, the first choice is relatives living in the same village. The second choice is close neighbours, friends or labourers working on the cattle owner's farm, and the last choice is farmers with a favourable reference from a person known by the owner. Cattle owners who entrust animals to others generally claim that landless farmers tend to be better carers than those who farm land for crops, because they can concentrate on the management and feeding of animals. The landless are also thought to be more motivated because they rely more on animals than do households with land. The landless farmers expect that by keeping a shared cow they may themselves own valuable capital in the form of a calf at some time in the future.

3.3.4. Importance of sharing animals

As noted above, households who cannot purchase cattle have to start with shared animals. If all goes well, they will eventually have animals of their own and sell progeny to obtain the funds needed to improve the house, or to rent or purchase extra land. The cash earned from selling cattle is also used to finance wedding parties. The

Table 3.1. Proportion of respondents (%) in the ranking priority of rearing cattle.

Aim of keeping cattle	Rank assigned by farmers					No priority
	1	2	3	4	5	
Putukrejo (n=150)						
Progeny	22	44	22	6	0	6
Manure	67	33	0	0	0	0
Weight gain individual animal	0	0	11	33	56	0
Draught	6	11	61	17	0	5
Savings	6	11	6	39	38	0
Kedungsalam (n=398)						
Progeny	52	37	6	0	0	5
Manure	25	34	21	16	1	3
Weight gain individual animal	0	3	9	9	28	51
Draught	6	6	18	16	9	45
Savings	17	21	38	17	0	7

history of several households included in the 12 case studies clearly indicates the importance of this role of livestock and the institution of sharing. However, one of the households included in the case studies, which had progressed from a situation with shared animals to a situation with a number of own animals, sold the animals it owned but retained them on the farm as shared animals. From that moment onwards the benefits from the animals obtained had to be shared with the new owner, but this disadvantage was compensated by the release of funds for purchase of land. In another case, a similar transaction took place and the money released that way was used to cover the initial expenses of renting land and planting sugarcane. The direct result of such a transaction is that a farmer who earlier reared only own animals, becomes a rearer of shared animals. Thus, whereas at the earlier stages of economic development of the household progress is associated with replacing shared animals by owned animals, at later stages of development the reverse could be true.

3.3.5. Obligations and rights of cattle owners and sharers

The initiative for a sharing contract can be taken by the owner as well as by the candidate sharer. Because of the socio-economic position of the latter, however, the initiative most often comes from the owner. There is no written sharing contract. Nevertheless, the conditions of sharing are well defined. The rearer of shared animals is responsible for the daily management of animals. He must inform the owner when the animal is in calf, about to calve or ill. The sharer can use the manure and can use the animal for draught power on his own land. With prior agreement from the owner, the sharer may also use the animal(s) to plough the land of others, or rent the animal(s) to other farmers for ploughing. The period of time that the shared animal and, if female, her offspring will be on the sharer's farm is not stipulated in advance. In principle, both the sharer and the owner have the right to terminate the sharing contract at any time. The time when offspring should be sold is negotiable. If the sharer dies, the sharing contract is automatically terminated.

There are two types of contract: one regulating the sharing of profits, the other regulating the sharing of offspring. Though there are exceptions (see below), sharing profit normally applies to male animals, whereas sharing offspring applies to females.

The principle of sharing profit is that when the shared animal is sold, the initial value, i.e. the value of the animal when it entered the sharer's farm, is deducted from the selling price and the difference is divided equally between the owner and the sharer. The rules are the same in Putukrejo as in Kedungsalam. Shared cattle are sold only when both the sharer and the owner agree to sell the animal. The reason for sale is often that either the owner or the sharer needs cash immediately. This may lead to frequent and sudden transactions. In one case for example, a young bull was sold 55 days after it arrived on the sharer's farm, because the sharer needed cash to cover medical expenses for his wife. Another reason for a sudden transaction can be that the animal is ill and expected to die. Such animals are sold for very low prices.

The sharing offspring contract applied to female animals is much more complicated than sharing profit contracts, because benefits can be in the form of property rights to progeny or cash. In this case there is also a difference between Putukrejo and Kedungsalam. In Kedungsalam, if the animal is one year old or younger when it arrives on the sharer's farm, the sharer is entitled to the first-born calf and the owner to the second calf. If the animal enters the sharer's farm at an age of more than one year, the first calf will go to the owner and the second to the sharer. In both cases property rights to the third and following calves are divided on a fifty-fifty basis between the cow's owner and the sharer. In Putukrejo, if the animal entering the sharer's farm is one year old or less, the owner will get one-third and the sharer two-thirds of the value of all offspring produced during the rearing period. If the animal is more than one year old when entering the sharer's farm, the value of all offspring will be divided on a fifty-fifty basis. Thus, if the animal is less than one year old at the beginning of the contract period, the owner in Putukrejo gets a smaller share in the progeny but receives the first return sooner. If the animal is more than one year old when it arrives on the sharer's farm, the owner in Kedungsalam gets a bigger initial return, without the decrease in the overall return that occurs in Putukrejo. In both villages, it holds that if a cow is already in calf when it arrives on the sharer's farm, the first calf goes to the owner and the second to the sharer. Thereafter the fifty-fifty sharing of progeny applies.

If one of the partners wants a shared calf entirely for himself or herself, the rules of *susuk-simusuk* apply: the partner who wants to get the calf must pay half the value of the animal in cash to the other partner. Similarly, if one partner needs cash, the other partner must pay half of the value of the animal. The calf must be at least eight months old for this. When a shared cow has had two calves and no transaction has yet taken place, the owner and the sharer of the cow are both entitled to 50% of the value of both calves. If one of the partners wants to have the bigger calf for himself he must pay half of the difference in value between the big and the small calves to the partner who will keep the smaller calf. This arrangement is only possible when the younger calf has reached the age of eight months and its value can be assessed.

Although the initial agreement for female cattle is usually of the sharing offspring type, this may be changed if the animal is found to be infertile or if either the owner or sharer needs immediate cash. In such cases, the principle of sharing profit may be applied. In the case of infertility, the owner may replace the animal with another cow or heifer. Cows are considered to be infertile if they do not become pregnant after being served five times or more.

3.3.6. The role of traders

Monetary values of animals are always decided upon with the assistance of a cattle trader. There are three categories of cattle traders in the area. Big cattle traders (*blantik gede*), usually belong to the village elite, have capital and means of transportation, and move from village to village. They purchase animals either directly from the farmers or from small local traders (*blantik cilik*). A third category are the *blantik nampar,* persons who are hired by the *blantik gede.* Their role is to bring animals to the market and sell them on behalf of the big cattle traders. In both Kedungsalam and Putukrejo, the assessment of the value of animals under sharing arrangements is done by the small local trader (*blantik cilik*). This assessment is made on behalf of both the owner and the sharer. The trader receives Rp. 1000 to Rp. 2000 (1 US$ = 2100 Rp.) from the owner of the animal for this task.

In the case of male animals and sharing profit contracts the *blantik cilik* assesses the value of the animal at the beginning and end of the rearing period. The price depends on physical characteristics such as colour, teeth, age, size and weight. Using these criteria the animal is valued according to the locally prevailing price. The value of mature cattle ranges from Rp. 400 000 to 800 000. The role of the trader is not only to arrive at 'a good standard price' but also to avoid conflicts between owner and sharer arising from a different perception of the value of the animal. This assessment of the value of animals is an essential part of both the sharing profit and the sharing offspring agreements. The value of a calf is assessed when the animal is weaned at the age of about eight months.

3.4. Discussion

Cattle are an important asset for resource-poor farmers in the limestone area. By selling cattle, the farming households can earn a relatively large amount of cash which can be used to improve their possessions or to cover major expenses incurred in the household cycle. Sharing systems have a supportive role in gradually improving or maintaining the standard of living. The current prerequisites for becoming a cattle sharer show that in principle a farm may have access to shared animals if the farmer has enough family labour to collect forage and has prior experience with rearing ruminants. The latter implies that young couples with no experience in rearing ruminants are excluded from the benefits of rearing cattle, unless they have funds to purchase animals themselves. One option open to such couples is to start with small ruminants. If the couple is able to build up the right social network and is accepted by the part of the community which controls the cattle resources, they may obtain a shared animal after their children are about ten years old and can help to collect forage.

The land characteristics and major activities of wealthy villagers influence land use systems and the farmers' access to cattle. Compared with Kedungsalam, farmers in Putukrejo have a better chance of obtaining shared cattle from the wealthy villagers. This is because the wealthy villagers in Putukrejo, i.e. the sugarcane owners, also want to maximize benefits from their land under sugarcane. Apart from producing cane, the sugarcane area also produces sugarcane tops, ratoon and sugarcane leaves which can be used as cattle feed. Sharing out cattle to labourers and giving them priority to use the tops of canes they harvest, effectively gives the sugarcane farmer extra income from cattle and also binds labourers more closely to his farm. Sugarcane was introduced around the year 1978 and from that moment this process gradually developed. In Kedungsalam, it is difficult to obtain cattle from wealthy villagers, i.e. the kiln owners. This is because these members of the community prefer to invest their capital in limestone burning. The kiln owners believe that the demand for labour to burn limestone in the dry season may compete with the demand for labour to collect forage. To produce 5.5 t of lime from a kiln in Kedungsalam (the average production of lime per burning, taking about two weeks) requires 540 labour hours (van Helden, 1991). However, data on labour hours needed to collect forage in Kedungsalam indicated that the labour requirements for feeding one animal are on average only 34 hours per fortnight.

Nevertheless, there are several ways for poor farmers in Kedungsalam to gain access to cattle e.g. by sharing animals owned by better-off relatives or friends living in the same village or elsewhere. Many start off by sharing small ruminants from better-off farmers. In addition, people who have left the village to get a better income in the city regularly send remittances to their families in the village. Whenever possible, these remittances are converted into cattle.

During the survey period both the proportion of farms with shared cattle and the proportion of shared cattle increased. This increase was more pronounced in Putukrejo than in Kedungsalam. This difference is related to the land use systems. The changes in cattle ownership were affected by the shortage of feed during the dry season of 1991. In that season, farmers in Putukrejo who had difficulty in finding forage had to purchase rice straw. In Kedungsalam, shortage of forage also occurred but the forest area in this village could, to some extent, buffer the need for forage. In Putukrejo, many farmers had to sell their animals to the better-off farmers, though they retained these animals on the farm as shared animals. The price of animals dropped by about 30 per cent in this period of forced sale. There is an indication that the money obtained through this procedure was used not only for rice straw to feed the cattle but also to purchase staple foods (van Rheenen, personal communication). So, changes in ownership of cattle act as a buffer against periods of drought. Pronounced dry seasons like the one in 1991 have occurred erratically in 30% of the last 20 years.

As already noted, the main reasons most farmers keep cattle are to produce progeny and manure (Table 3.1). The first aim can be justified by the fact that, whether rearing shared or own cows, the progeny provides the farmer with an additional tradable asset. Manure is considered essential to maintain soil fertility in the area. To optimize the limited amount of manure available, farmers do not spread the manure on their field but they put the manure in the hole where maize seed will be planted (Sunaryo, personal communication).

Sharing has received little attention in the literature. However, studies on the feasibility of new technologies should consider the sociological factors involved in keeping livestock, because both types of actors that play a part in livestock keeping, i.e. the sharers and the owners, must accept an intervention. It can be concluded that sharing practices result in a more optimal use of the resources labour, capital and feed at village level. For the subsistence farming households, lack of cash to purchase cattle is not a limiting factor for acquiring cattle. These households have to build up the right social network so that they gain access to cattle owners and can offer their excess labour for cattle rearing.

THE RELEVANCE OF CATTLE FOR LAND CULTIVATION

4

4.1. Introduction

It is usually said that animals, cattle in particular, are kept in small-scale mixed farming systems because they are a way of accumulating capital and they contribute to crop production (Beets, 1990; Devendra, 1993[a]). They do this by concentrating nutrients from wastelands, roadsides, home gardens and crop residues in the form of manure, and by supplying power for the cultivation of arable land. Farmers in Putukrejo and Kedungsalam attach lower priority to the use of cattle for land cultivation than to manure production. In Kedungsalam, a considerable number of farmers (about 45%) did not see animal power as a motive for keeping cattle (Table 3.1).

Most of the literature on draught animals focuses on their importance for draught purposes and how this operation can be improved, rather than first examining the relevance of draught animals in a specific farming system. Soil type, soil quality and terrain characteristics are important variables determining whether cattle are used for draught purposes (Huitema, 1982; Petheram *et al.*, 1985; Falvey, 1987; Pearson, 1993). In areas with steep slopes, it is reported that the risk of erosion often prevents the use of animal-drawn cultivation equipment (Ramm *et al.*, 1984; Falvey, 1987). Additionally, better soil preparation, which is often associated with cultivating the land by hand, can lead to higher yields (Palte, 1989). On the other hand, the use of cattle for cultivation is reported to be of the utmost importance in order to enable the largest possible area to be prepared in a short time span, especially if climatic conditions are less favourable, e.g. if the wet season starts later than usual and there is considerable pressure of time (Huitema, 1982). This chapter discusses the relevance of cattle for land cultivation in Putukrejo and Kedungsalam.

4.2. Methods

Data on labour allocated to different operations of crop cultivation in 35 farm households in Putukrejo and Kedungsalam were recorded by the INRES Intensive Farm Household Survey, from November 1990 to October 1991. If the land was cultivated manually, the number of hours worked were recorded for all people working on plots of a specific household. If cattle were used, the ploughman and his animals were considered a team and the hours worked on a specific job were taken into consideration as the hours worked by the ploughman. The area cultivated was calculated cumulatively, which means that if a plot was cultivated repeatedly, its area was counted the same number of times.

Soil and terrain characteristics in both Putukrejo and Kedungsalam were defined by the INRES soil scientists in Land Units (LU), which refer to areas with uniform physical and chemical soil characteristics (Table 4.1). Four LUs were distinguished along a toposequence from valley bottom (LU1) to hill top (LU4). The quality of land in terms of moisture retention capacity and nutrient availability decreases roughly along the toposequence from LU1 to LU4. The LUs were classified according to soil depth, slope (terraced or not), fertility of topsoil, stoniness and presence of rock outcrops. LUs 1 and 2 are considered most suitable for arable farming, whereas LUs 3 and 4 represent land hardly suitable for arable farming. The distribution of the different land classes (Table 4.2), studied on 150 farm households (Cornelissen *et al.*, 1996) indicated that Putukrejo is endowed with a high percentage (95%) of arable farm land (LU1 and LU2) while more than half (58%) of the land in Kedungsalam is of poorer classes (LU3 and LU4).

4.3. Results

4.3.1. Tillage and other agricultural activities

Figure 4.1 shows how much time is spent on different cropping and livestock activities. Tillage, preparing the seedbed, fertilizing and weeding coincide in a few months just before and just after first rainfall (October until January) and again when land for the second crop is prepared (March). Time pressure on labour allocation is especially high in these periods. But even when time pressure is high, the use of cattle for land cultivation is a small fraction of total tillage activities at that time. At the highest peak in September 1991 the use of cattle for land cultivation was approximately 16% of all tillage activities in Kedungsalam. In Putukrejo this was about 20%.

Table 4.1. Definition of Land Unit (LU) used for the classification of lands operated by farmers in Putukrejo and Kedungsalam (Stroosnijder *et al.*, 1994; Efdé, 1996).

	Land class			
	LU1	LU2	LU3	LU4
Soil depth (cm)	>75	>75	50-75	<25
Soil texture[1]	+++	++	+	-
Terracing[2]	+++	++	+	-
Slope (%)	<3	3-15	15-50	>50
Position	valley	slope	upper slope	hill crests

[1] Soil texture: heavy clay with no stones (+++) to clay with many stones (-)
[2] Terracing: fully terraced (+++) to not terraced at all (-)

Table 4.2. Distribution of land classes (% of total area operated by 150 farm households).

Land Units	Putukrejo	Kedungsalam
1 and 2	95	42
3 and 4	5	58

4.3.2. The area cultivated and labour allocated to land cultivation

The total amount of labour allocated to agricultural activities per farm household per year is lower in Kedungsalam (2103 h) than in Putukrejo (3342 h). The proportion of labour allocated to tillage using cattle in both villages is similar but small, i.e. 1.1% and 0.9% in Putukrejo and Kedungsalam, respectively.

Table 4.3 gives the area cultivated using cattle or using hand labour, and the time spent on these activities, in both villages. It is important to notice the high coefficients of variation, i.e. a large variation between households in a village. Nevertheless, the data indicate that approximately one third of the area in Putukrejo is cultivated using cattle. In Kedungsalam, in comparison, this is only 8%. Similarly, in Putukrejo approximately 18% of the total labour allocated to tillage is allocated to tillage using animal power, where in Kedungsalam this is only 9%.

In Table 4.4 the data from Table 4.3 are shown separately for LUs 1 and 2,

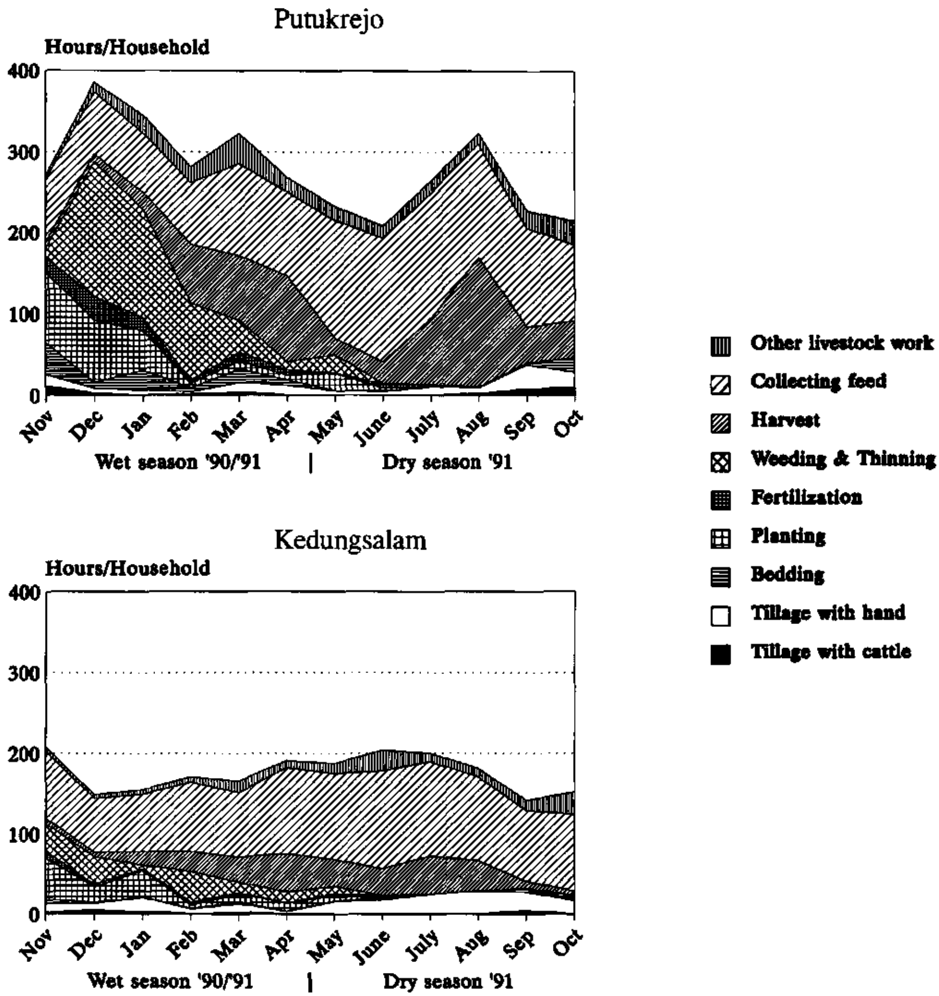

Figure 4.1. Time spent per month on specific agricultural activities in the period November 1990 to October 1991.

representing better land, and LUs 3 and 4, representing poorer land. In both villages only a small fraction (14 and 6%, respectively) of the poorer land was cultivated using cattle. The same was true for LUs 1 and 2 in Kedungsalam (11%). In Putukrejo, however, more than one third (35%) of the better land was cultivated by cattle. Thus, the higher proportion of total land in Putukrejo being cultivated using cattle results from the combined effect of two factors: (1) Putukrejo has a higher proportion of LUs 1 and 2, and (2) farmers in Putukrejo use cattle on these LUs more than farmers in Kedungsalam. This suggests that farmers in Putukrejo take land quality into account

Table 4.3. Average area cultivated per household (ha) and the average time spent (h) on tillage per household using cattle or hand labour.

	Putukrejo			Kedungsalam		
	Area		C.V.[1]	Area		C.V.
Cattle	0.82	(31%)	143	0.23	(8%)	152
Hand labour	1.80	(69%)	80	2.56	(92%)	143
Total	2.62	(100%)		2.79	(100%)	
	Time spent			Time spent		
Cattle	26.2	(18%)	140	14.7	(9%)	167
Hand labour	121.9	(82%)	96	156.9	(91%)	105
Total	148.1	(100%)		171.6	(100%)	

[1] Coefficient of variation

Table 4.4. Average area cultivated per household (ha) and the average time spent (h) on tillage per household over land classes using cattle or hand labour.

	Putukrejo				Kedungsalam			
	LU 1/2		LU 3/4		LU 1/2		LU 3/4	
	Area				Area			
Cattle	0.76	(35%)	0.06	(14%)	0.13	(11%)	0.10	(6%)
Hand Labour	1.44	(65%)	0.36	(86%)	1.05	(89%)	1.51	(94%)
Total	2.20	(100%)	0.42	(100%)	1.18	(100%)	1.61	(100%)
	Time spent				Time spent			
Cattle	25.8	(19%)	0.4	(3%)	10.9	(12%)	3.8	(5%)
Hand labour	110.6	(81%)	11.3	(97%)	77.2	(88%)	79.7	(95%)
Total	136.4	(100%)	11.7	(100%)	88.1	(100%)	83.5	(100%)

when deploying cattle for land cultivation. The time spent on cultivation by hand and cultivation with cattle for the two land classes shows a similar trend, but in this case the difference between the two villages is less pronounced.

In Table 4.5 the ratio time spent on cultivation and the area cultivated is shown for LUs 1 and 2. The ratio for LUs 3 and 4 was not considered because of the very small area cultivated by cattle in Putukrejo. Farmers in Kedungsalam need a similar amount of time to cultivate one ha by cattle (approx. 84 h ha^{-1}) or by hand (approx. 74 h ha^{-1}). Farmers in Putukrejo needed a similar period (approx. 77 h ha^{-1}) for cultivation by hand. In contrast, farmers in the latter village needed less than half (approx. 34 h ha^{-1}) for cultivation by cattle.

4.4. Discussion

As is often the problem with studies of this type, there was a great variation between farms that operate under similar internal and external conditions (Teleni *et al.*, 1993). This is expressed by the high coefficients of variation in Table 4.3. As a result the differences observed were not statistically significant. Nevertheless, tendencies in the use and relevance of cattle for land cultivation can be discussed in relation to the different land use systems that were observed for Putukrejo and Kedungsalam (see Section 2.9).

The use of cattle for land cultivation as such can be seen as an absolute criterion which can simply be given as a yes or no. As an absolute criterion cattle were used for land cultivation in both Putukrejo and Kedungsalam. However, their use was limited to those months that land preparation is done and even their use for land cultivation was only a small fraction of the total tillage activities during peak periods (see Figure 4.1).

The average area cultivated per household per year using cattle was larger in Putukrejo than in Kedungsalam: almost one third of the area cultivated compared to 8% in Kedungsalam. Separated into two land classes the data indicate that especially in Putukrejo cattle were used to cultivate the better land, whereas in Kedungsalam cattle were used for land cultivation on only a small fraction of both the better and the poorer land.

One striking result was that the efficiency of land cultivation using cattle was much higher in Putukrejo (approx. 34 h ha^{-1}) than in Kedungsalam (approx. 84 h ha^{-1}) on areas in the same land class. These differences in the area cultivated using cattle and in the efficiency of cultivation within one land quality class between the two villages might be the result of land use in Kedungsalam being dominated by agroforestry (see Section 2.9) where trees are randomly distributed over the fields (Overmars and Sunaryo, 1991), which hampers ploughing.

Conclusions to be drawn, depend on the level at which the data are analysed. At

Table 4.5. Ratio between the time spent on land cultivation and the area cultivated (h/ha) for LUs 1 and 2.

	Putukrejo	Kedungsalam
Cattle	33.9	83.8
Hand labour	76.8	73.5

village level (Table 4.3), it appears that soil and terrain characteristics are the main factors determining the relevance of cattle for land cultivation. At farm level (Table 4.4), however, soil and terrain characteristics do not seem to have a direct influence on the decision whether to use cattle for land cultivation or not. The land use system seems to have much more effect on this decision. Of course, soil and terrain characteristics then have an indirect effect, because of their influence on land use.

Assuming that cattle work for 4 h d^{-1}, the average number of working days of cattle per farm household in Putukrejo is 9 d y^{-1} and in Kedungsalam is 5 d y^{-1}. Comparing these figures with data given by Petheram (1991) on the working days of draught animals (buffaloes) in the irrigated paddy fields in Java (100-200 d y^{-1}), shows that animals are far less important for land cultivation in the upland areas than they are in the lowland areas.

In the literature on the use of animals for draught purposes it is often stated that it is highly likely that animals will provide a considerable proportion of the power on small farms for the foreseeable future or even that the importance of draught animal power will even increase in the South-East Asian region (Smith, 1990; de Guzman and Petheram, 1993; Pearson, 1993). The data obtained in the villages of Putukrejo and Kedungsalam indicate that one should be very careful when making such statements especially for specific farming systems. Even in neighbouring villages the factors that determine whether a farmer decides to use cattle for land cultivation or not may differ greatly. In the case of Putukrejo and Kedungsalam the decision largely depends on the land use system. Although, some farmers prefer to use cattle rather than hand labour to cultivate land, probably because of their long experience and traditional values (Teleni *et al.*, 1993).

CATTLE IN A FARM HOUSEHOLD PERSPECTIVE 5

5.1. Introduction

Farm households in the limestone area of South Malang are involved in the production of annual and perennial crops, keeping ruminants and doing on-farm non-agriculture and off-farm work (Chapter 2). Cattle are the most prevalent type of ruminant. To understand the prospects for cattle in the limestone area their benefits for the farm households must be known.

Cattle produce both physical and intangible products. The physical products liveweight gain, manure and draught power all together result in value added. This value added results from the use of the household's production factors land, labour and capital, and it represents a major production indicator of the farm households.

The capital embodied in animals kept and the possibility of disposing of animals as and when required results in benefits not captured in value added. The animals enable the farm household to meet unexpected expenditures. This potential represents a form of security for which an insurance premium must be paid in situations where an insurance market exists. The benefits from this depend on the farmer's ability to meet uncertain financial requirements and they can be assessed by considering alternative insurance options. Disposing of animals as and when required means that financing through formal or informal agents can be avoided; this means a saving on transaction costs. These transaction costs can be considerable: formal institutions charge interest rates from 3% to 5% per month and travel expenses and time spent must be added; informal agents in Java may charge an interest rate from 10% to 20% per month (Bouman and Moll, 1992). The intangible products are important in areas lacking developed financial markets and formal insurance (Bosman and Moll, 1995; Binswanger and Rosenzweig, 1986; Von Pischke, 1983). Bosman and Moll (1995) found that goat keeping in South-Western Nigeria served as insurance and finance mechanism and that these benefits were four times higher than the value added.

Arable land in the area is intensively used for crop production to secure a basic income for the farm household in terms of food and cash. No land is specifically allocated for forage. Forages for cattle, including grass, tree leaves and crop residues, are collected daily from on-farm and off-farm sources. Thus labour for the collection of forage is a major input into the cattle sub-system.

As already noted, the cattle kept by farmers may be owned or shared. Farmers with shared cattle obtain only part of the income from the liveweight gain of the cattle and their progeny, but have the full right to the manure and draught power produced (Chapter 3).

This chapter aims to quantify the benefits of cattle for the farm household. Two analyses of the relevance of cattle in the farm household's perspective are presented. The first, based on a smaller sample, deals with the value added of cattle, the returns to labour or capital and the intangible benefits. The second, based on a larger sample, estimates the contribution of cattle to the farm household income.

5.2. Methods

5.2.1. Production

Nineteen out of the 35 farm households included in the Intensive Farm Household Survey in Putukrejo and Kedungsalam kept cattle. They comprised eight farm households with own cattle only, four with shared cattle only and seven with own plus shared cattle. The live weight of the individual animals and the dynamics of the herds were monitored monthly from January to December 1991.

Physical

Production in terms of live weight was measured using the formula:
$(S - P) + (T_o - T_i) + (E - I)$ where:

- S = the live weight of cattle sold
- P = the live weight of cattle purchased
- T_o = the live weight of cattle transferred out
- T_i = the live weight of cattle transferred in
- E = the live weight of cattle at the end of the survey
- I = the live weight of cattle at the beginning of the survey.

The value of individual cattle was based on the animal's live weight, using the equation: value (in *rupiah*, Rp[1]) = $930 * [1 - e^{-0.0050*LW}] - 111$, where LW is the animal's live weight (in kg). This equation was based on 29 head of cattle (live weight range from 88 kg to 414 kg) sold by the 19 farm households in 1990 and 1991.

Production of manure per kg metabolic live weight ($LW^{0.75}$) of cattle was estimated at 31 g Dry Matter (DM) d^{-1}. The hours that cattle were used for land

1) 1 US$ = Rp. 2 100

cultivation were recorded.

Value of manure was calculated as the total DM of the manure produced times the estimated price per kg DM of manure. Based on its nitrogen, phosphorus and potassium contents, Sabon (1993) calculated that the price per kg DM of manure in Putukrejo and Kedungsalam was Rp. 35. The common price of hiring cattle for land preparation in the area was Rp. 600 h^{-1}.

The average value of all cattle per farm household y^{-1} was calculated to represent capital used for production. The average number of cattle per farm household was calculated as the total observation days per animal divided by 365 observation days (Hermans *et al.*, 1989). The average calving interval was estimated by summing the number of cow observation days and dividing this by the number of births (Udo *et al.*, 1990).

The sum of values of the different physical products minus expenditure forms the added value. Expenditure includes the cost of repair and maintenance of sheds. The added value can be allocated to the production factors labour and capital; land plays a very limited role as a production factor.

The labour used for the collection of forage per farm household was calculated by multiplying the total number of Animal Units (AU) in the farm by the average time spent for forage collection per AU. This was then converted to mandays (md) by assuming an eight-hour working day (Sutrisno, personal communication). The AU of an individual animal was the $LW^{0.75}$ of the animal divided by 62.8 kg, i.e. the metabolic weight of a 250 kg animal. The average time spent for forage collection per AU was based on data collected from May 1990 to October 1991 in the above 19 farm households. In that period, an enumerator spent a whole day on the farm once a month, to record the time spent collecting forage. This was divided by the total number of AUs on the farm to estimate time spent for forage collection per AU.

Intangible

The intangible benefits from insurance are expressed as an amount per year: $B_i = b_i$ * average herd value during one year. As there are no institutional insurance services accessible to rural households, the factor b_i was set at 6% (Moll, personal communication). This represents the insurance premium that would have to be paid if there were insurance markets. The intangible benefits from financing were based on the average sales, as this represents the part of the herd actually used to meet household requirements. Hence, $B_f = b_f$ * average sales. The factor b_f can be estimated by considering alternative ways of obtaining credit. In this section it is estimated at 6%, a rate in between formal and informal interest rates for one month. The intangible benefits neccessarily involve arbitrary estimates for b_i and b_f, but this directly results from absent or incomplete markets for insurance and finance.

5.2.2. Contribution to farm household income

From November 1990 to October 1991 the Expanded Farm Household Survey (EFHS) of INRES gathered data on the activities and the related inputs and outputs of 150 randomly selected farm households in Putukrejo and Kedungsalam. Of the 150 respondents, seven in Putukrejo and six in Kedungsalam earned more than Rp. 15 x 10^6 y^{-1}. In Putukrejo, these were the owners of relatively large sugarcane fields while in Kedungsalam they were lime traders. Therefore these 13 farmers were considered to be outliers and were excluded from the analysis. Of the 137 farm households, 57 reared cattle and 27 reared cattle in combination with small ruminants. Income from various farm household activities for farms with cattle and farms without cattle was analysed.

Land operated by the respondents were classified into four Land Units (LU) as already given in Chapter 4. *Tumpang-sari* land (TSL) was added to define forestry area leased by the respondents to grow maize and cassava. The size of each LU per farm household was measured. The sum of the LU and TSL areas per farm household represents farm size.

On-farm labour was provided by the members of the farm household and was expressed in Adult Worker Equivalent (AWE). One AWE was defined as a person between 15 and 65 years of age. Children between 10 and 15 years and people over 65 were defined as 0.5 AWE.

The farm household income is the sum of farm income and income from on-farm non-agriculture and off-farm work. The farm income is the sum of income from crops (annuals and perennial) and livestock (cattle, goats and sheep). Income from crops was calculated as price per kg of product times the total production of the crop minus variable costs except household labour. So, crop income includes home consumption and cash income. To ascertain the income from livestock, the survey recorded income obtained from sales. The reasons for the sales were also recorded. Added value from cattle was estimated from the survey described in Section 5.2.1.

Income from on-farm non-agriculture and off-farm activities were receipts minus variable costs. Income from non-agriculture included home industry, lime burning, collection of limestone, bamboo weaving, carpentry, making mattresses, charcoal production, running a small shop, sewing, trading, working as wage labourer, driver, factory worker and remittances. Major contributor to on-farm income in Putukrejo was small shops and in Kedungsalam lime burning. Major contributor to off-farm income in Putukrejo was labouring in agriculture and in Kedungsalam labouring for the lime traders.

Least squares methods were used to explain variations in farm income for farms with cattle, without cattle and both in relation to differences in farm household resources. The analytical model included the effect of the villages and the covariables age head household, labour on-farm, number of cattle, goats and sheep and the area per land class.

5.3. Results

5.3.1. Production

Table 5.1 shows the average resources used and the production of cattle per farm household observed in the 19 farm households. All variables have a large variation. Due to this, differences between the villages and between farms with different types of ownership of cattle were not statistically significant. So, data for the two villages and the different ownership categories were pooled.

On average, 74 kg of live weight was produced per farm household y^{-1} from an average of 452 kg cattle weight per farm household, implying a liveweight productivity of 16%. The live weight increase came mainly (68%) from calves, and gain of calves represented 75% of the total value of the live weight produced per farm.

Of the initial number of owned cows (11 head), only two were purchased and the others were obtained through sharing. During the observation period, only one animal was purchased (by a farmer in Kedungsalam who earned substantial income from lime burning and received a remittance). Twelve calves were born during the observation period. Calves are commonly weaned between 8 to 12 months. During lactation, the live weight of cows decreased by approximately 50 kg in 8 months. The calculated calving interval was 32 months. On average, 1.2 t y^{-1} manure DM was produced and the cattle were used for, on average, 28 h for land preparation.

The different physical products gave an added value of Rp. 235 000 per farm household. This resulted from an average capital of Rp. 954 000 and labour of 196 md. If all the value added is allocated to labour, the return to labour is Rp. 1200 md^{-1} and if all the value added is allocated to capital, a return to capital of 25% is obtained. In addition to the added value, the cattle gave financing and insurance benefits which resulted in a total income from cattle keeping per farm household of Rp. 305 000 y^{-1}.

Table 5.1. Resources used and production of cattle per farm household.

	Mean	C.V.[1]
Resources:		
No. of cattle (head)	1.9	59
Total liveweight of cattle (kg)	452	46
Total value of cattle (Rp 1000)	954	46
Labour used (md y^{-1})	196	80
Expenditure[2] (Rp 1000 y^{-1})	3	
Production y^{-1}		
Liveweight (kg)	74	84
Manure (kg DM)	1256	48
Draught power (h)	28	92
Value of products y^{-1} (Rp 1000)		
Liveweight	177[4]	
Manure	44	
Draught power	17	
Total	238	
(Sales)[3]	(210)	
Added value (Rp 1000)	235	
Benefit from financing (Rp 1000)	13	
Benefit from insurance (Rp 1000)	57	
Total Livestock Income (Rp 1000)	305	

[1] Coefficient of variation
[2] Estimated cost for repair and maintenance of livestock sheds
[3] Sales were higher than liveweight production implying a decrease of the herd
[4] 75% came from calves

5.3.2. Contribution to farm household income

Resources

The area farmed per farm household was slightly smaller in Putukrejo (0.78 ha) than in Kedungsalam (0.97 ha). However, the farm area in Putukrejo comprised better land (mainly LU2) and in Kedungsalam it was poorer land (more LU4). The average number of household members was 4.5; in terms of labour 3 AWE per farm

Table 5.2. Means and coefficients of variation (C.V.) of resources of farm-households with (+) and without (-) cattle.

Variables	Putukrejo				Kedungsalam			
	+ Cattle		- Cattle		+ Cattle		- Cattle	
	Mean	C.V.	Mean	C.V.	Mean	C.V.	Mean	C.V.
No. of households	22		21		62		32	
Age household head (y)	44	20	45	36	45	27	43	37
Farm size (ha)	0.8	89	0.8	80	1.2	63	0.8	78
Household members	4.3	34	4.0	36	4.7	37	4.6	34
On-farm labour (AWE)	3.0	40	2.5	44	3.4	41	3.2	41
Cattle (head)	2.0	34	-	-	2.0	50	-	-
Goats (head)	0.4	316	-	-	0.7	192	1.1	148
Sheep (head)	0.1	327	0.2	317	0.2	328	0.5	202
LU1 (ha)	0.2	131	0.1	185	0.2	121	0.1	203
LU2 (ha)	0.5	96	0.6	103	0.3	103	0.2	160
LU3 (ha)	0.1	160	0.1	165	0.1	143	0.1	222
LU4 (ha)	<0.1	0	<0.1	0	0.5	123	0.3	122
TSL (ha)	-	-	-	-	0.1	209	0.1	183

household. Resources other than cattle of farms with and without cattle in each village did not differ (Table 5.2).

Farm household income

In Putukrejo, crop production was the major source of income of farms with (66%) or without (72%) cattle (Table 5.3). On farms with cattle, cattle and small ruminants contributed 26% to the farm household income. The contribution of cattle to farm household income was higher than the contribution of on-farm non-agriculture and off-farm activities (8%). On farms without cattle the absence of income from ruminants was compensated by higher income from on-farm non-agriculture and off-farm activities (28% of farm household income). So, the total farm household income was similar for both types of farms.

In Kedungsalam, crop production was also the major source of farm household income on farms with cattle (46%), followed by cattle (28%), on-farm non-agriculture and off-farm activities (25%), and small ruminants (1%). On farms without cattle, crop production gave less income than on farms with cattle. The low income from crop production and the absence of income from ruminants on farms without cattle

Table 5.3. Means and coefficients of variation (C.V.) of total farm household income y^{-1} and its components (Rp. 1000) for farm-households with (+) and without (-) cattle.

	Putukrejo				Kedungsalam			
	+ Cattle		- Cattle		+ Cattle		- Cattle	
	Mean	C.V.	Mean	C.V.	Mean	C.V.	Mean	C.V.
No. of households	22		21		62		32	
Maize	96	41	163	96	48	124	19	110
Cassava	107	74	91	89	124	189	89	125
Rice	166	156	73	216	187	194	88	342
Other[1]	5	317	10	321	14	649	8	349
Perennials[2]	54	130	118	178	128	164	67	141
Sugarcane	364	228	383	189	-	-	-	-
All crops	792	132	838	109	501	109	271	127
Cattle[3]								
added value	235	-	-	-	235	-	-	-
intangible benefits	70	-	-	-	70	-	-	-
total	305	-	-	-	305	-	-	-
Small ruminants	7	327	-	-	6	393	11	282
On-farm non-agriculture and off-farm income	95	262	333	319	273	304	574	202
Farm household income	1199	-	1171	82	1085	-	856	115

[1] Chili, soyabean, long bean, vegetables

[2] Jackfruit, avocado, mango, banana, mlinjo (*Gnetum gnemon*), coffee, coconut, kapok, firewood, teak tree and bamboo. In Putukrejo, kapok was the main component and in Kedungsalam coconut

[3] See Table 5.1.

was partly compensated by a high on-farm non-agriculture and off-farm income (67%).

Crop income in Putukrejo was higher than in Kedungsalam. This was because farmers in Putukrejo obtained a considerable amount of income from sugarcane production on top of the income obtained from traditional crops (maize, cassava, rice, others and perennials). In Putukrejo, sugarcane comprised 46% of total crop income in farms with and without cattle. Farmers in Putukrejo were able to grow sugarcane partly because they own larger areas of land of better quality (LU2) compared with farmers in Kedungsalam and partly because the marketing infrastructure for sugarcane is well established in Putukrejo.

Cattle are not sold with a view to maximize profit but mainly because of the need for cash to cover costs needed for enlarging farm size i.e. renting and purchasing land (Table 5.4). Cattle selling is also related to fulfilling family obligations such as conducting festivities related with the life cycle, house improvement and covering general household needs such as the purchase of food. In the area, sick cattle that are expected to die are commonly sold at low prices. This practice leads to very low actual cattle mortality rates. Those who had not sold cattle during the survey period mentioned that cattle would be sold when cash was needed. The prices ranged from Rp. 250 000 to Rp. 750 000 with a direct relationship to live weight, see Section 5.2. None of the farmers sold farmyard manure. Renting out cattle for draught purposes was negligible.

Factors affecting farm income

All variables selected had very large coefficients of variation (Table 5.2 and 5.3) indicating that farmers in the two villages were not homogeneous. The least squares analysis (Table 5.5) shows that farm income of both farm categories and of all farms in Putukrejo does not differ significantly ($P>0.05$) from that in Kedungsalam.

Table 5.4. Reasons for selling cattle in the two villages.

Reasons	No. farm households
High price/profitable moment	-
Cattle too old	-
Cattle sick, expected to die	3
Cattle infertile	1
Covering costs of festivities	3
Covering general household costs	6
House renovation	4
Renting land	5
Purchase of land	3

Table 5.5. Least squares means (L.S. Mean) and regression coefficients for various farm parameters with farm income (Rp.1000) as dependent variable for farms with cattle (+ Cattle), without cattle (- Cattle) and all farms.

Factors	+ Cattle		- Cattle		All	
	L.S. Mean	S.E.[2]	L.S. Mean	S.E.	L.S. Mean	S.E.
Overall average	706	85	530	74	653	57
Villages[1]:						
Putukrejo	758	162	627	140	754	107
Kedungsalam	655	88	433	107	552	67
	Regression[3]		Regression		Regression	
Age head household (y)	-7	7	4	5	-1	4
Labour on-farm (AWE)	-31	59	8	68	-14	43
Cattle (head)	2	88	-	-	11	49
Goats (head)	43	59	-70	67	26	42
Sheep (head)	-206	138	108	96	10	79
LU1 (ha)	1264***	332	369	563	1046***	259
LU2 (ha)	1101***	250	910***	179	921***	149
LU3 (ha)	789	451	1182*	514	782*	334
LU4 (ha)	-35	154	76	368	12	130
TSL (ha)	659	478	1655*	795	919*	378
R^2full model[4] (%)	44		54		42	

[1] Means were not significantly different ($P > 0.05$)
[2] Standard error
[3] Significance levels: *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$
[4] Coefficient of determination

The greatest sources of variation in yearly farm income in farms with cattle were the size of LU1 and LU2 ($P < 0.001$) and in farms without cattle the size of LU2 ($P < 0.001$) followed by the size of LU3 and TSL ($P < 0.05$). Overall, the sizes of LU1 and LU2 were the major sources of variation determining farm income ($P < 0.001$), followed by the size of LU3 and TSL ($P < 0.05$). Each of these variables had a positive effect on farm income. An increase of one hectare of LU1, for example, was estimated to contribute Rp. 1 046 000 to farm income. Age of the head of the household, on-farm labour, and the numbers of ruminants did not have a significant ($P > 0.05$) effect on farm income.

5.4. Discussion

Farm size is commonly found as the major factor that positively affects crop income in upland farming areas in Java (Atmadilaga, 1992; Nibbering, 1991; Widodo *et al.*, 1994). In Putukrejo and Kedungsalam, crop income is the major component of farm income. The latter is significantly affected by the possession of better quality land i.e. LU1 and LU2. With larger areas of LU1 and LU2, farmers in Putukrejo produce a higher crop income, mainly by growing sugarcane, than farmers in Kedungsalam. To supplement income from crops, farmers in both villages have the option of keeping cattle or doing on-farm non-agriculture and off-farm work. This choice will depend on the opportunities the farmers have to get access to cattle and to on-farm non-agriculture and off-farm work. In Kedungsalam, for example, farmers have the option of being involved in lime burning or working as labourers in the lime burning industry. However, the capacity of this sector is limited. About one-third of the farm households in Kedungsalam devote their labour to crops and on-farm non-agriculture and off-farm employment rather than to keeping cattle. In Putukrejo, about half of the farm households choose for crops and on-farm non-agriculture and off-farm activities rather than keeping cattle. The on-farm non-agriculture and off-farm activities that provide a significant income are agricultural work or running a small shop. The agricultural work can be related to the existence of a relatively large sugarcane production (occupying ca. 50% of the total arable land) in Putukrejo that can absorb labour throughout the year. Putukrejo is more isolated than Kedungsalam, so, for many households running a small shop is a sensible option.

Apart from LU1 and LU2, LU3 and TSL had also a positive impact on farm incomes. The LU3 and TSL are commonly used for growing maize intercropped with cassava. The total area of LU3, TSL and LU1 per farm household in both villages at present is less than the area of LU2. Fragmentation of farms due to inheritance, as commonly happens in Java, also occurs in the two villages (Atmadilaga, 1992; Solichin, 1996). This may lead to a further decrease of all types of LUs per farm household in the future. This survey shows that with smaller size of LU1+LU2 per farm household (Kedungsalam), activities that are not dependent on farm size (i.e. cattle, non-agriculture and off-farm activities) become more important to supplement the income from crops.

The physical production of cattle mainly consists of live weight gain, and obviously calves are the major contributor to this. At least two aspects need further attention if liveweight production is to be increased: reproduction and calf growth. With regard to reproduction, apart from long calving intervals as mentioned in Section 5.3.1, farmers complained about the late maturity of the heifers i.e. first estrous is between three to four years. Farmers do not see calf growth as a problem. However, infections of endoparasites were identified. Nearly all calves in the study area were infected with *Toxocara vitulorum* (Cornelissen, 1991; Ifar and Trisunuwati, 1992).

Manure is considered essential to maintain soil fertility in the area (Chapter 2) and farmers place a high value on it. The estimation of the monetary value of manure is based on the nutrient contents (N, P and K). This results in a conservative estimate, as organic matter and micro minerals are ignored.

The combined physical production of cattle results in an added value of Rp. 235 000 per farm per year. Allocating this added value over the two production factors is arbitrary, but if a realistic return to capital of 6% is taken (a nominal interest of 16% on savings minus an inflation rate of 10%), the return to labour is Rp. 907 per day. The latter amount is below current daily wages but it must be borne in mind that keeping cattle means secure employment for about 200 days per year per household.

The additional benefits from cattle through their role in financing and insurance add a substantial amount (30%) to the added value derived from cattle. The estimation of the benefit factors (b_f and b_i) used in this section are open for discussion, and the estimated addition to the income of Rp. 70 000 per farm per year is merely an indication. Better estimates require a detailed study of the households' perception of future and thus uncertain financial requirements and their abilities to meet these through other mechanisms.

The total contribution of cattle to the farm household income in both villages is much lower than the contribution of cropping activities. In farms with cattle, the contribution of cattle is higher than the contribution of on-farm non-agriculture and off-farm activities. In both villages a farmer with two head of cattle has a capital of Rp. 954 000 which can at any time be converted into cash, and this amount of capital is higher than the yearly income from other activities. To obtain such an amount of capital, farmers would need to save all earnings from 636 days working as labourer or selling 4.8 t of maize or 17.3 t of cassava. Such a saving, however, is difficult to realize because income from labour is used directly to finance daily consumption. Also, it would be impossible to sell these amounts of maize or cassava. First, because yields that high are impossible on the small cropping area per farm household and given the soil's low organic matter content. Second, some (if not all) of the crop products are used for home consumption. Cattle thus provide a convenient savings mechanism.

Most farmers did not sell any animals during the survey period. These farmers could also not define in advance when cattle would be sold. The present study shows that cattle are used to finance anticipated 'large' expenditures and contingencies neccessary to secure and to improve the farm household economy. Farmers with cattle in Putukrejo and Kedungsalam could generate cash to an amount of Rp. 489 000 (the average selling price) by selling one animal. This equals the price of 611 kg of good quality rice in the urban market. This amount of rice can meet the consumption needs of a farm household with four members for 306 days. Hence, if a sudden crop failure occurs, farm household consumption could be secured by disposing one animal. Two head of cattle would provide even more security. A farm with two head of cattle could enlarge the area of better quality land through renting or purchase, provided such land is on offer. A substantial receipt from lime burning and remittances was converted by one of the farmers into cattle. This represents the farmers' strategy to secure their 'substantial' income against losses due to e.g. theft, spending or social pressure to lend cash to relatives or neighbours. In doing so, the value of the receipts can be retained until cash is needed.

Hence, the gradual increase in live weight of cattle and their capacity for reproduction, provide farmers with a suitable means of accumulating wealth which requires few monetary inputs. The possibility of converting cattle into cash at any time further adds to the attractivity of cattle keeping. These capabilities contrast with crop production, as crop products can only be used or sold on or after a fixed point in time. Stored crop products decline in quantity and quality and therefore lose value. The physical production and the intangible benefits of cattle are thus important to support and improve the farm household's economy.

AVAILABILITY AND UTILIZATION OF FORAGES 6

6.1. Introduction

All the arable land in the limestone area of South Malang is used for cropping. There is hardly any open grassland and fallow where ruminants can graze. The INRES reconnaissance survey (Chapter 2) showed that feeds are collected both on- and off-farm in a cut-and-carry feeding system. Forages of different quality, including crop residues, grass and tree leaves, are available in varying amounts in different parts of the year, depending on rainfall and cropping calendar.

Where feed resources comprise forages of different quality, farmers can select only the better materials to compose rations of higher quality and meet the requirements for higher production per animal, or use all feeds to feed more animals. In both cases the number of animals should be in balance with the amount and quality of feeds available, taking into account the seasonal distribution of forage quantity and quality. This chapter presents an analysis of the feed resources in Putukrejo and Kedungsalam, the way in which these are utilized and the actual physical production of livestock.

6.2. Methods

6.2.1. Forage availability

Data on the availability of forages in Putukrejo and Kedungsalam were collected by means of a survey carried out in the period May 1990 to October 1991. Data on land use were mostly obtained from village records. These records did not reflect the recent increase in the area under sugarcane in Putukrejo and the resulting decrease in the area of rice. Therefore, sugarcane and rice fields in this village were mapped and the area estimated using a planimeter. For both villages, the area of native grass on the sides of roads and paths was estimated by multiplying the length of roads and paths (measured using a motorbike) by the average width of the grassy verges (measured every 0.5 km).

The production of native grass on the verges of roads and paths, and on *bongkoran* was monitored monthly, using a 0.5 by 0.5 m quadrat on 40 to 50 sites in each village. On roadsides, the sampling sites were two km apart, on *bongkoran* 50 paces (approx. 45 m).

The amount of crop residues (maize, cassava, rice, and sugarcane) per ha was measured on the plots of 30 farmers (out of the 35 included in the INRES intensive farm household survey; 12 in Putukrejo and 18 in Kedungsalam) during the harvesting period of the crop in question. The amount of weeds collected in the weeding period was also measured. The monthly distribution of materials becoming available at harvest was estimated by multiplying the area harvested each month by the average yield per ha. The area harvested monthly was estimated by multiplying the total area of the crop by the proportion harvested in that month. For maize, cassava, *sawah* rice and upland rice, the latter value was derived from data on cropping patterns collected on the same farms by the INRES agronomy section. The area of sugarcane harvested monthly was taken from the records of the sugarcane cooperative in Putukrejo.

Apart from grass, weeds and crop residues, farmers also feed considerable amounts of tree leaves. In all, 34 species were recorded. All of these, except gliricidia (*Gliricidia sepium*) are usually mixed, in very small quantities per species, with native grass harvested on *bongkoran* and forest areas. Gliricidia leaves are harvested both on- and off-farm, and the trees are subjected to various management systems. The INRES agronomy section counted the number of trees on the 12 farms in Putukrejo and 18 farms in Kedungsalam mentioned above. For both villages, the total number of trees on-farm was estimated by multiplying the respective mean values by the number of farms in these villages. Estimates of the number of trees off-farm (mainly on *bongkoran*) were based on the average number per ha (estimated by the INRES agronomy section; based on observed planting distances) and the total area of *bongkoran* controlled by the Department of Forestry in the two villages. The yield of leaves per tree depends on the management system, i.e. pollarding or stripping. Pollarding involves removing the whole branch. Stripping involves leaving the branches on the tree, but stripping off all the leaves except for those near the end of the branch (about 25 cm from the branch tip). Yields for both management systems were estimated by the INRES agronomy section on 4 sites where trees were lopped or stripped, at intervals of three months. Monthly yields of leaves were calculated, assuming that the number of trees from which leaves are harvested is equally divided between months, but taking into account the difference in yields per tree between the dry and wet season. Dry and wet seasons (May-October and November-April, respectively) were distinguished on the basis of average rainfall data measured in Pagak, in the period 1960-1991 (see Chapter 2).

6.2.2. Forage utilization

Eighteen farms with cattle (9 in Putukrejo and 9 in Kedungsalam) were visited periodically in the period May 1990 to October 1991, covering three seasons: dry season 1990, wet season 1991 and dry season 1991. At the beginning of the study, the total number of cattle held on these farms was 29 (16 in Putukrejo and 13 Kedungsalam), including calves, heifers, bulls and cows. Of the 18 farms studied, eight reared owned cattle, six reared shared cattle only and four reared both owned and shared cattle.

Each farm was visited once every six weeks, approximately; there were 219 visits in total. On each visit, an enumerator stayed on the farm for one day (24 h), to record the type and weight of forage collected by the farmers, the labour used for collecting the forage, the classes of animals present on the farm (calf, heifer, bull or cow), the type of ownership (owned or shared) and the live weight of the animals. Calves include all animals from birth to weaning (on average at about 10 months age). Weaned female animals were classified as heifers until their first partus. Thereafter they were classified as cows. All weaned males were classified as bulls. The labour used in forage collection was expressed in Adult Working Equivalent (AWE) as defined in Section 5.2.2.

In many cases, the forage collected by the farmers was a mixture rather than of a single type. When this was the case, it was separated into different components: native grass and weeds, elephant grass, gliricidia, tree leaves (other than gliricidia), sugarcane forage (including tops, ratoon and leaves), cassava leaves, maize straw and rice straw. The amount of feed offered was expressed per kg metabolic weight ($LW^{-0.75}$). When the forage collected was fed to more than one animal, the total amount of feed was divided by the summed metabolic weight of the animals.

6.2.3. Nutrient concentration and digestibility

Samples of all forage types were taken on each of the 219 farm visits. Samples per forage type were bulked per season. At the end of each dry and wet season, sub-samples were taken for analysis on dry matter (DM), organic matter (OM), crude protein (CP) concentration and *in-vitro* organic matter digestibility (OMD). The analyses were performed in the animal nutrition laboratory of the Animal Husbandry Faculty of Brawijaya University. For sugarcane tops and rice straw, *in-vivo* OMD values were measured in trials conducted in August 1990 and August 1991 on three farms in Putukrejo, using bulls present on these farms. The Metabolizable Energy (ME) concentration of each forage was calculated by assuming 15.8 kJ ME per g

Digestible Organic Matter (DOM) (NRC, 1981). The results of these analyses were used as an estimate for the nutrient concentration and digestibility of forages available at the village level and used by farmers to compose rations. The nutrient concentration and digestibility of the rations offered were calculated from the proportion of individual feeds in the ration.

6.2.4. Liveweight gain of cattle

During the above visits the live weight of animals present on the farms was also recorded with a portable scale. Liveweight gains per animal were calculated separately for each season as the live weight at end of the season minus the weight at the beginning of the season, divided by the number of days in between.

6.2.5. Village herd size

Estimates of the number of ruminants, expressed in Animal Units (AU) were based on the survey carried out in January 1991 (see Section 3.2). Cattle were divided into the classes mature (older than three years), medium (weaned animals younger than three years) and young (suckling calves). Small ruminants were classified as mature when they were older than 1.5 years. Based on the survey sample, the proportion of farms keeping cattle, sheep and goats and the average number of animals per farm household were calculated. These data were combined with the total number of households in each village (1012 in Putukrejo and 2256 in Kedungsalam, based on the village records) to estimate the total number of animals. They were then converted to Animal Units (AU) using different conversion factors per age class. The conversion factors were based on the average metabolic weight ($LW^{0.75}$) of animals in each age class as measured on the 18 farms mentioned in Section 6.2.2, divided by 62.8 i.e. the metabolic weight of a 250 kg animal.

6.2.6. Analysis of variance

Data on nutrient concentration of the rations fed, amount of DM, CP, DOM offered and liveweight gain were subjected to analysis of variance. The preliminary analysis indicated that interactions between variables were not significant. For the final analysis the following general model was used:

$$Y_{ijkl} = \mu + V_i + F_j + S_k + E_{ijkl}$$

Y_{ijkl} : parameter concerned
μ : mean
V_i : villages; i = 1, 2 (Putukrejo and Kedungsalam)
F_j : farm types; j = 1, 2, 3 (farms with owned cattle only, owned and shared cattle, shared cattle)
S_k : seasons; k = 1, 2, 3 (dry season 1990, wet season 1991, dry season 1991)
E_{ijkl} : error

For the analysis of data on liveweight gain the type of animal (calf, heifer, bull, cow) was also included in the model.

6.3. Results

6.3.1. Forage availability

6.3.1.1. Land use

The major forms of land use and the areas involved, as recorded at the village offices of Putukrejo and Kedungsalam, are given in Table 6.1. In Putukrejo, 54% of the total area is arable land (*tegalan* and *sawah*), compared with only 33% in Kedungsalam. In the latter village, 33% of the total area is covered by forest and 14% by government estates. Due to the higher population density in Putukrejo, a larger proportion of the land in this village is occupied by buildings. The area occupied by settlements as indicated in Table 6.1 includes the buildings as well as home gardens (*pekarangan*).

6.3.1.2. Forage resources

Arable land

In Putukrejo, the presence of a considerable area of deep soils enables farmers to grow sugarcane. Sugarcane was first introduced as a cash crop in Putukrejo in 1978 and this has had a major effect on the availability of animal feed in the form of cane tops in the harvest season, as well as leaves and ratoon in seasons that no tops are available. At present, about 260 ha (50% of the *tegalan*) is used to grow sugarcane and this area is still expanding. Forty percent of the *tegalan* in Putukrejo is used for intercropping maize and cassava and 10% for upland rice. According to the village statistics, 80% of the 1416 ha of *tegalan* in Kedungsalam is used for intercropping maize and cassava,

Table 6.1. Land use (1989).

Land use[1]	Putukrejo		Kedungsalam	
	ha	%	ha	%
Tegalan	516	47	1416	32
Sawah	75	7	31	1
Bongkoran	172	16	378	9
Perkebunan	0	0	630	14
Hutan negara	0	0	1441	33
Settlements	197	18	417	10
Lain-lain	137	12	61	1
Total	1097	100	4374	100

Source: Anonymous (1989c,d)
[1] For explanation of Indonesian terms see Table 2.1

15% for upland rice and 5% for sugarcane. Field observations indicated, however, that sugarcane was no longer being grown in this village.

In both villages, the semi-irrigated land (*sawah*) is used only for growing rice. The irrigation water comes from springs and is channelled through small ditches. In the dry season, however, water supply is limited and not enough for irrigation. Hence, only one crop of rice can be grown per year.

Bongkoran

Eighty percent of the *bongkoran* in Putukrejo, and 65% in Kedungsalam is owned by the Department of Forestry. The remaining 20% in Putukrejo is divided between 40% of the farmers in that village, while the remaining 35% in Kedungsalam is divided between 70% of the farm households.

The most common forages produced on *bongkoran* owned by farmers are gliricidia and native grass. About 12% and 38% of the *bongkoran* area owned by the Department of Forestry in Putukrejo and Kedungsalam, respectively, was planted with gliricidia more than ten years ago. The rest of the Department of Forestry *bongkoran* is open native grass land (dominated by *Imperata cylindrica*) with scattered shrubs.

The Department of Forestry planted gliricidia to protect the area from erosion and to enhance soil fertility by nitrogen fixation. These aims, however, are being thwarted in Putukrejo. In this village, the gliricidia on Department of Forestry land is frequently pollarded by farmers for forage. As a result canopies are usually small and less leaves than envisaged are available for mulching. Farmers in Kedungsalam rarely pollard their trees. The most probable explanation why farmers in Putukrejo pollard gliricidia but those in Kedungsalam do not, is that most farmers in Kedungsalam have more gliricidia available on-farm than their counterparts in Putukrejo.

Government estates

The government estate area is managed by the Department of Forestry to produce timber from teak, mahogany and albizia trees. The undercover of native grass is used as forage by farmers.

Natural forest and tumpangsari

The Southern part of Kedungsalam is largely covered by natural forest. Based on information from village officials and farmers, and own observations, it is estimated that 5% of the natural forest area is used as a source of forage (native grass and tree leaves) by farmers.

In addition to the maize+cassava and rice mentioned above for Kedungsalam, these crops are also grown on so-called *tumpangsari* land, i.e. land from which the forest has been cleared. In Table 6.1 this area (120 ha) is included in natural forest. Since 1987, the Forestry Department has cleared forest to plant albizia (*Albizia falcata*) for timber. The *tumpangsari* area is divided into 0.25 ha plots, each with five rows of albizia, spaced five m apart. These plots are contracted to farmers for a period of three years after they have been cleared and planted with albizia. During this period, the farmers are allowed to grow annuals on the open area between the albizia, in return for looking after the growing trees. This land use is absent in Putukrejo. In 1990, about half of the *tumpangsari* area was used to grow dry land rice and the other half for maize+cassava. In 1991, nearly the whole *tumpangsari* area was planted with maize intercropped with cassava.

Roadsides

Grass on roadsides (including the verges of paths) is an important source of forage. The most common grasses include *Polytrias amaura, Cynodon dactylon, Cyperus sp.* and *Kylinga sp.* The estimated area of roadside grass in Putukrejo is 4 ha, compared with 10 ha in Kedungsalam.

Field borders and pekarangan

In addition to the gliricidia on *bongkoran*, farmers in both villages also plant gliricidia for firewood and forage in the *pekarangan*. Especially in Kedungsalam, gliricidia is also found along the border or scattered on maize+cassava plots. As a result, the number of gliricidia trees planted on-farm is much higher in Kedungsalam than in Putukrejo (see Table 6.2). The larger amount of gliricidia in Kedungsalam is partly explained by the lime burning industry in this village. Even though only a limited

Table 6.2. Proportion of respondents (%) classed by the number of gliricidia trees planted on-farm and the average number (Mean) and standard deviation (S.D.) of trees in each class.

Number of gliricidia trees planted on-farm	Putukrejo			Kedungsalam		
	% of farmers in this class	Number of trees in this class		% of farmers in this class	Number of trees in this class	
		Mean	S.D.		Mean	S.D.
101 - 500	80	308	126	-	-	-
501 - 1000	-	-	-	50	767	125
1001 - 2000	20	1906	7	17	1402	167
2001 - 5000	-	-	-	11	2865	574
5001 - 10000	-	-	-	17	6363	822
>10000	-	-	-	5	12529	200

Source: INRES Agronomy data base

number of the wealthier villagers is directly involved, it stimulates farmers to grow gliricidia trees to produce firewood to be sold to the kiln owners.

Some farmers grow elephant grass (*Pennisetum purpureum*) on the bunds of arable fields. Cuttings are planted about 0.5 m apart in rows. Elephant grass was introduced in Putukrejo and Kedungsalam in 1987 by farmers returning from visiting relatives in the eastern, more humid, part of the limestone area (Dampit) where this grass is commonly planted for forage. The estimated area of field bunds under this grass in Putukrejo and Kedungsalam is, however, small (2 and 5 ha, respectively). Many farmers are not interested in growing this grass because its production is very low during the dry season.

6.3.1.3. Forage yields

Effect of rainfall

Figure 6.1 shows the monthly rainfall and the cropping pattern for the period of observation. Rainfall in the 1990 dry season (May-October) was similar to the 32-year average value in Pagak for this period of the year (total of 440 mm for the six months, mean 73 mm $month^{-1}$). The same was true for the 1991 wet season: total 1481 mm, mean 247 mm $month^{-1}$). On the other hand, the 1991 dry season, with hardly any rain from May to October, was unusually dry. This variation in rainfall caused large

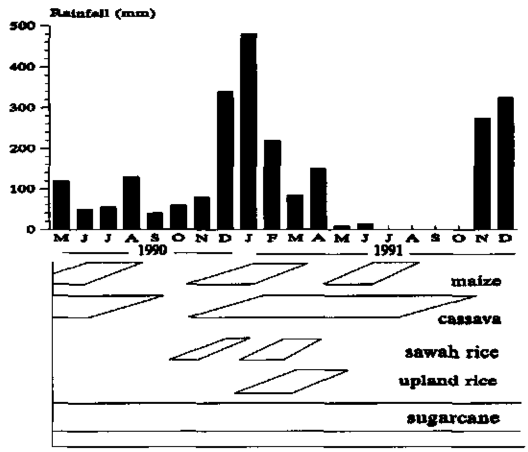

Figure 6.1. Rainfall and cropping pattern in Putkrejo and Kedungsalam from May 1990 to December 1991.

differences in the seasonal availability of forages. For some feeds, for example maize straw, differences in availability mainly reflect whether only one or two crops can be grown. After the relatively mild dry season of 1990, most farmers could plant their maize and cassava, and upland rice, in October. Thus two crops of maize could be harvested in 1991. In 1991, on the other hand, farmers could not start to prepare their land until November and did not start planting until late December. Under such conditions, it may not be possible to harvest two crops of maize. For other feeds, such as grass and sugarcane tops, the area may remain the same, but the yield per season or per harvest is significantly reduced during periods of drought.

Grass

Figure 6.2 shows the variation in availability of native grass from roadsides and *bongkoran* during the period of observation (data for Putukrejo and Kedungsalam were pooled as they were not statistically different ($P > 0.05$)). Although there was a dip in the yield of grass from roadsides in June-August 1990 and in that from *bongkoran* until October, the average monthly yield of DM for the period May-October 1990 (462 kg ha^{-1} on roadsides and 265 kg ha^{-1} on *bongkoran*) was similar to that in the following wet season (460 and 285 kg ha^{-1}, respectively). Yields dropped to very low levels after April 1991. Roadsides and verges produced no grass at all in the period July to October 1991 and on *bongkoran* the yields were zero from June to October 1991. The onset of the rains in November 1991 led to the rapid increase in the amount of grass on roadsides and on *bongkoran*. The yields were consistently higher on roadsides than on *bongkoran*. This may be attributed to the grass cover being less

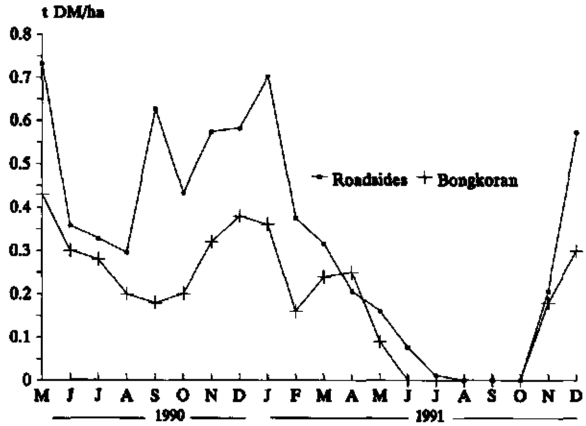

Figure 6.2. Monthly native grass production per hectare on roadsides and *bongkoran*.

dense on *bongkoran* than on roadsides and verges. In Kedungsalam, farmers collect considerable amounts of grass, often mixed with some tree leaves, from the forest and government estates, in the dry and wet seasons. The estimated yield from these areas was 200 (Standard Deviation = 183) kg DM ha^{-1} $month^{-1}$.

The estimated production of elephant grass on field bunds was 10.2 (S.D. = 5.7) t DM ha^{-1} y^{-1}, but, as noted above, the area is very small. Moreover, most of the production is realized in the wet season. Production in the dry season is very low.

Crop residues and weeds

Average yields of sugarcane forage and other crop residues, expressed in t DM ha^{-1} per harvest period, are shown in Table 6.3. The yield of weeds was insignificant compared to that of crop residues. All values mentioned in Table 6.3, except those for sugarcane tops, are means for all harvest periods.

The sugarcane in Putukrejo is produced under the ratoon system. This yields three types of cane forage in different periods of the year: tops, ratoon and leaves. The tops (consisting of green leaf-blades and the tip of the cane, covered by leaf-sheaths), become available during the harvesting period of the crop, mostly in the period June to October. The yield of 7.6 t DM ha^{-1} is for 1990. Due to the drought in 1991, yields in that year were much lower (4.2 t DM ha^{-1}).

The ratoon comprises leaves and young stems, obtained when the cane clumps are thinned after four months of regrowth. Most of this becomes available in the period October to February. The crop is thinned to reduce the number of shoots to a maximum of seven per clump. Most farmers consider thinning important to achieve good yields. Hence thinning is practised on nearly all (90%) of the sugarcane area.

Table 6.3. Average production (t DM ha^{-1} $harvest^{-1}$) of crop residues.

Crop residue	Mean	S.D.[1]
Maize leaves	2.8	1.4[2]
Cassava leaves	0.5	0.2[2]
Rice straw	5.7	1.8[3]
Sugarcane: tops	7.6	2.0
ratoon	1.7	0.7
leaves	3.6	0.8

[1] Standard deviation
[2] Data from Putukrejo and Kedungsalam were pooled as they were not statistically different ($P>0.05$)
[3] Effect of village and land use type (*sawah* and upland rice) were not significant ($P>0.05$)

The yield of 1.7 t DM ha^{-1} refers to the area actually thinned.

The third forage from sugarcane, leaves, consists of the greenish leaves lopped off the cane several months before this is harvested. This is done on about 50% of the total sugarcane area, mostly in the months February-June. Farmers who do not lop their cane, believe that lopping has little advantage and merely increases costs of labour. The yield of 3.6 t DM ha^{-1} refers to the area where this was actually practised.

Gliricidia

In Putukrejo, the trees are generally pollarded, while in Kedungsalam they are either pollarded or stripped. The stripping method is applied to trees used for the production of heavier firewood. After one or two years, the stripped branches reach the right size and then are also pollarded. These heavier branches are used for burning lime. Some of the leaves are used for forage, but most are incorporated in the soil. Half of the gliricidia trees grown on the *bongkoran* owned by farmers in Kedungsalam are pollarded and the other half are stripped for forage. For trees on the land of the Department of Forestry this ratio is about 4 to 1.

In the wet season, the estimated amount of edible material produced by gliricidia was 26.9 g DM $tree^{-1}$ $month^{-1}$ under the pollarding method and 14.5 g DM $tree^{-1}$ $month^{-1}$ under the stripping method. The dry season production under both harvest methods of gliricidia grown on the *bongkoran* owned by farmers was half of the production recorded in the wet season. The dry season yields from pollarded and stripped trees on Department of Forestry *bongkoran* was only 10 per cent of the values measured in the wet season.

6.3.1.4. Monthly total quantities per village

The estimated monthly amounts of DM of all forages produced in Putukrejo and Kedungsalam during the whole period of study are depicted in Figure 6.3. Numerical data are given in Appendix 1. The pattern of total amount of DM available differed for the two villages. In Putukrejo, relatively short periods of far below average availability occurred in May 1990 and November 1990, May-June 1991 and towards the end of the dry season of 1991. The pattern in Kedungsalam, on the other hand, was characterized by relatively short periods of far more than average values (July 1990, January-March 1991 and July 1991).

Not only the total amount of DM available, but also the composition showed a large seasonal variation and considerable differences between the two villages. Whereas in Putukrejo there was a nearly continuous supply of sugarcane forage with peak amounts during the dry season, there is no sugarcane forage in Kedungsalam. In Kedungsalam, larger and relatively constant amounts of grass and gliricidia leaves were available throughout the year. In both villages this was supplemented with periodically available residues of maize and rice. Maize leaves were mainly available from January to March and June or July (in both villages) and rice straw in December 1990 - January 1991 (mainly in Putukrejo), and from March to May 1991 (both villages). Cassava leaves were mainly available during the dry season, i.e from April to September, with a peak in July-August, and in larger quantities in Kedungsalam than in Putukrejo.

The effect of the 1991 drought on availability of DM in the dry season was stronger in Putukrejo than in Kedungsalam. In the former village the total amount of DM available during the dry season of 1991 was reduced by 41% as compared to the dry season of 1990. In Kedungsalam yields were reduced by only 10%. The large decrease in Putukrejo was mainly due to a 50% decrease in the amount of sugarcane tops and the fact that the availability of native grass fell to nearly zero during the 1991 dry season. In Kedungsalam, no grass was available from roadsides and *bongkoran* during the 1991 dry season, but considerable amounts of grass were still available from the forests and estate areas.

6.3.2. Nutrient concentration and digestibility

The seasonal variation in DM content and nutritive value within forages was small compared with the differences between forages. All forages, including rice straw, had below 40% DM. Mean values per forage type for the concentration of OM and CP, OMD and concentration of ME are given in Table 6.4. Cassava tops and gliricidia are

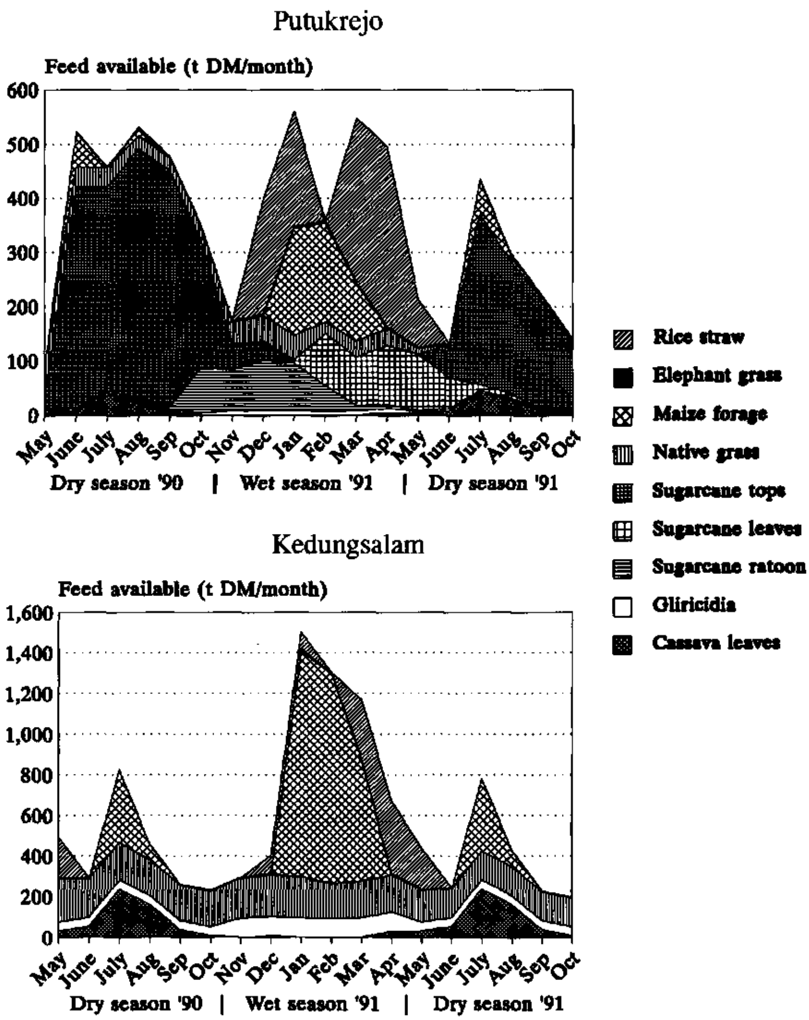

Figure 6.3. Amount of feeds available from May 1990 until October 1991.

the best forages, with CP and OMD ranging from 18% to 21% and 69% to 80%, respectively. Sugarcane ratoon, leaves and tops can be considered as good forage with regard to energy. Their OMD ranged from 64% to 67%. The concentration of CP is, however, low, ranging from 5.0% to 7.3%. Native grass, maize leaves and elephant grass are of medium quality with OMD ranging from 53% to 55% and CP from 7.8% to 9.5%. Rice straw is low in OMD (50%) as well as CP (4.5%).

Based on OMD, forages in Putukrejo and Kedungsalam could be divided into 3 classes: (1) digestibility >75%: cassava leaves; (2) digestibility 64-69%: gliricidia, sugarcane ratoon, leaves and tops; (3) digestibility 50-54%: native grass, maize leaves,

Table 6.4. Quality of forages used in Putukrejo and Kedungsalam.

Name	OM (% in DM)	CP (% in DM)	OMD (%)	ME (MJ/ kg DM)
Cassava tops	88.8	21.4	79.5	1115
Gliricidia	90.8	18.4	68.7	986
Sugarcane ratoon[1]	85.4	7.0	67.0	904
Sugarcane leaves[1]	86.6	7.3	65.0	889
Sugarcane tops[1]	86.0	5.0	64.0	870
Native grass	77.6	7.8	54.8	672
Maize leaves	87.6	9.1	53.5	740
Elephant grass	81.9	9.5	52.6	681
Rice straw	76.4	4.5	50.5	610

Note: DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, OMD Organic Matter Digestibility, ME: Metabolizable Energy
[1] In Putukrejo only

elephant grass, and rice straw. Similarly, three classes can be distinguished with regard to the ratio total N / digestible organic matter: >0.045: cassava tops and gliricidia; 0.029-0.035: maize leaves and grass; 0.015-0.021: sugarcane forages and rice straw. Sugarcane tops have the lowest ratio: 0.015. Based on predicted estimated voluntary intake of ME (see Chapter 7) the classification would be: cassava tops and gliricidia 1.8-2.3 times maintenance; sugarcane forages: 1.2-1.4 times maintenance; native grass, maize leaves and elephant grass: 1.0 times maintenance; rice straw: 0.8 times maintenance.

The seasonal availability of individual forages causes large variations not only in the total amount of DM available but also in the monthly weighted means of CP concentration and OMD (see Figure 6.4). OMD values range from 54% to 66%. The seasonal pattern is similar for both villages but the number of months with low to medium values is higher in Kedungsalam than in Putukrejo. For CP concentration, differences between months were larger in Kedungsalam than in Putukrejo. Nevertheless, in all months except May 1990 the CP concentration was higher in Kedungsalam. The higher CP concentration in Kedungsalam is mainly caused by the larger amounts of gliricidia and cassava leaves in this village.

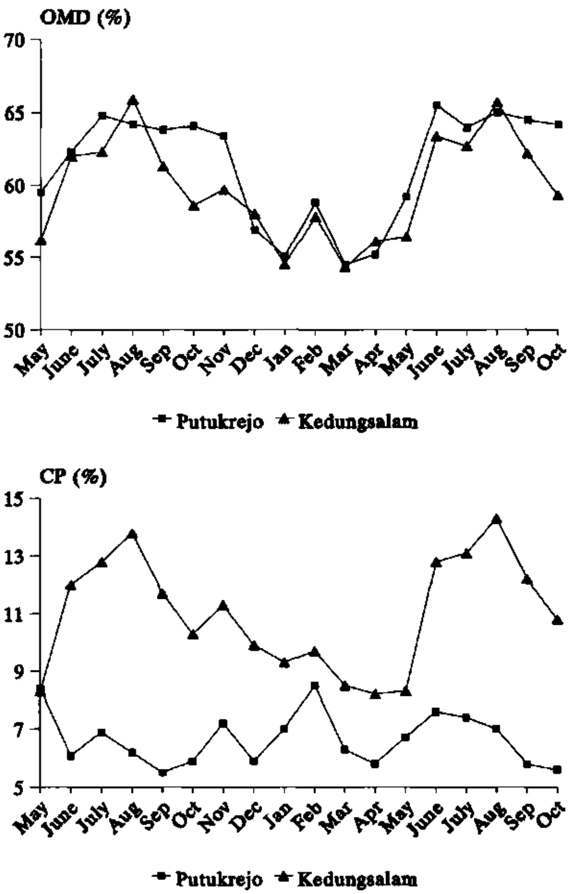

Figure 6.4. Monthly weighted mean of Organic Matter Digestibility (OMD) and concentration of Crude Protein (CP) of forage available from May 1990 to October 1991.

6.3.3. Forage utilization

6.3.3.1. Composition of rations

Table 6.5 shows the composition of the rations offered in different seasons from May 1990 to October 1991, together with the proportion of individual feeds in the forage produced (derived from Appendix 1).

In Putukrejo, sugarcane forage comprised a very large proportion of the feed offered, especially in the two dry seasons (51 and 40%, respectively). In the wet

Table 6.5. Proportion of individual feeds (%) in the forage produced (P) and the ration fed (F) by farmers.

	Dry season 1990		Wet season 1991		Dry season 1991		Total	
	P	F	P	F	P	F	P	F
Putukrejo								
Cassava	4	3	0	7	6	0	3	4
Gliricidia	1	7	2	13	2	9	1	9
Sugarcane forage	83	51	28	23	79	40	60	37
Native grass	8	22	9	31	1	18	7	24
Maize forage	3	3	19	17	5	3	10	8
Elephant grass	0	0	1	0	1	0	1	0
Rice straw	-	15	42	10	6	31	18	19
Kedungsalam								
Cassava	21	8	1	5	23	16	11	9
Gliricidia	10	25	11	34	11	21	11	27
Sugarcane forage	-	-	-	-	-	-	-	-
Native grass	43	31	21	28	37	28	30	30
Maize forage	17	6	51	16	19	13	35	11
Elephant grass	1	16	1	12	1	4	1	11
Rice straw	8	14	15	5	9	19	12	13

season too, sugarcane forage comprised nearly one quarter (23%) of the ration fed. Overall, however, the proportion of sugarcane forage in the ration fed was lower than in the forage produced, with the largest difference in the dry seasons. For cassava + gliricidia and native grass the the reverse is true: proportions in the ration fed were higher than in the forage produced. In all seasons the proportion of maize leaves in the ration fed was similar to the proportion in the feed produced. For the total period of 18 months, this was also true for rice straw, but in this case the proportion in the ration fed was much lower than that in the feed produced in the wet season, while the reverse was true for the dry season. In 1990, stored rice straw was used in May when the total amount of feed available was extremely low. In the second year, rice straw was used to correct the severe deficiency of feeds towards the latter part of the dry season when yields of sugarcane were reduced as a result of drought. For this purpose rice straw was imported from the lowland north of the limestone area.

For Kedungsalam, the major shifts were a higher proportion of gliricidia in the ration fed than in the forage produced and the reverse for maize. For the latter, this was mainly due to the difference between the ration fed and forage produced in the wet season. The data in Table 6.5 suggest that also in the dry season the farmers feed less maize forage than is produced in that season. This is not in agreement with other observations, namely that nearly all farmers store maize forage for feeding in periods when less feed is available, indicating a considerable transfer of maize forage harvested in February-April to the dry season. On the other hand, the data in Table 6.5 suggest that considerable amounts of cassava leaves available in the dry season are not utilized. This is in agreement with the statement of many farmers that they restrict the amount of this feed to avoid the danger of poisoning animals with HCN. Farmers generally state that they prefer not to include more that 10% cassava leaves in the ration. Observations for rice in Kedungsalam are similar to those noted above for Putukrejo. In all seasons, native grass + tree leaves and gliricidia were the major feeds in Kedungsalam.

The composition of the rations fed in Kedungsalam differed markedly from that in Putukrejo. In all seasons the ration contained a much higher proportion of feeds with a higher N/DOM ratio, in particular gliricidia (21-34% with a mean of 27%). In the 1991 dry season the proportion of cassava leaves was also much higher in this village than in Putukrejo.

6.3.3.2. Origin of forages

Table 6.6 shows that farmers in Kedungsalam collect a larger fraction of the ration on-farm (75%) than farmers in Putukrejo (28%). This is mainly because the major components of the ration in Kedungsalam i.e. gliricidia and native grass were more collected on-farm. Apart from these two forages, tree leaves in Kedungsalam were also collected more from on-farm resources. In Putukrejo, the major component of rations, i.e. sugarcane forage, was mainly (94%) obtained from off-farm resources. This was because none of the respondents grew sugarcane themselves. However, in May 1991, one of the respondents hired 0.5 ha to grow sugarcane.

Maize, cassava leaves and rice straw were also partly gathered from off-farm resources. Whereas 71% of the rice straw fed in Kedungsalam was obtained on-farm, the largest proportion of the rice straw fed in Putukrejo came from outside the own farm. This is at least partly because rice straw, which used to make up for the deficiency of feeds in the 1991 dry season, had to be collected from the lowland areas outside the village boundary.

6.3.3.3. Nutrient content of rations

The DM and CP content of rations fed in Kedungsalam were significantly ($P<0.05$) higher than in Putukrejo, but there was no significant ($P>0.05$) village effect for OMD (see Table 6.7). The values were not significantly ($P>0.05$) different between farm types. A significant ($P<0.05$) effect of season was found for the DM and CP

Table 6.6. Proportion of each forage type (% of total DM collected) from on-farm resources.

	Putukrejo	Kedungsalam
Grasses		
- Native grass	15	46
- Elephant grass	79	85
Gliricidia	46	83
Tree leaves	55	88
Crop residues		
- Sugarcane forage	6	-
- Cassava leaves	83	97
- Maize straw	85	82
- Rice straw	35	71
Weighted mean	28	75

Table 6.7. Least squares means (L.S. Mean) with standard error (S.E.) of dry matter (DM) and crude protein (CP) content and organic matter digestibility (OMD) of rations.

Source of variation	n	DM (%)		CP (% in DM)		OMD (%)	
		L.S. Mean[1]	S.E.	L.S. Mean[1]	S.E.	L.S. Mean[1]	S.E.
Overall	219	30.0	0.3	10.5	0.3	59.7	0.5
Village:							
Putukrejo	119	29.2[a]	0.4	8.8[a]	0.3	58.8[a]	0.6
Kedungsalam	100	30.5[b]	0.5	12.3[b]	0.4	60.1[a]	0.8
Farm type[2]:							
O	108	29.2[a]	0.4	10.2[a]	0.3	59.6[a]	0.7
OS	60	30.1[a]	0.5	11.2[a]	0.4	59.6[a]	0.9
S	51	30.2[a]	0.6	10.2[a]	0.5	59.2[a]	1.0
Season:							
Dry'90	70	29.4[a]	0.6	9.8[a]	0.5	60.1[a]	1.0
Wet'91	84	27.6[b]	0.5	11.8[b]	0.4	58.8[a]	0.8
Dry'91	65	33.3[c]	0.8	9.8[a]	0.7	57.2[a]	1.3

[1] Means with different superscripts are significantly different ($P<0.05$)
[2] O: farms rearing owned cattle only; OS: farms rearing owned and shared cattle; S: farms rearing shared cattle only

content of rations but not for OMD. DM was significantly lower in the wet season ($P<0.05$) than in the two dry seasons. The DM content of the ration was highest in the 1991 dry season. The highest ration CP was found in the 1991 wet season.

6.3.3.4. Amount of feed offered

The average amounts of DM and DOM offered were not significantly ($P>0.05$) different between villages (Table 6.8). But the amount of CP offered in Kedungsalam was significantly ($P<0.05$) higher than in Putukrejo. Farms keeping both owned and shared cattle (OS) offered significantly ($P<0.05$) less DM and DOM to their cattle compared with the other farm types. The amount of CP offered was not significantly ($P>0.05$) different between farm types. The amount of DM, CP and DOM offered was significantly lower in the dry season 1991 than in the other seasons.

6.3.3.5. Labour used in forage collection

Convenience is a factor taken into account by farmers in collecting forage. Farmers in Putukrejo mentioned that they prefer to collect crop residues instead of grasses or tree leaves. This was not mentioned by farmers in Kedungsalam. Table 6.9 confirms that less time is needed to collect crop residues in Putukrejo than to collect native grass or tree leaves.

In Kedungsalam, the times required for collecting tree leaves, grasses and crop residues (except maize leaves) were not significantly different. In both villages, collection of maize leaves is the most time efficient. There is no statistically significant difference between the two villages except for the longer period needed for collecting tree leaves in Putukrejo.

The labour used for forage collection includes persons from the household and other unpaid help. On average, 1.3 ± 0.1 AWE AU^{-1} d^{-1} was used for the collection of forage. This value was significantly ($P<0.05$) lower for farms keeping owned and shared cattle (1.1 ± 0.1 AWE AU^{-1} d^{-1}) than for the other farm types (1.4 ± 0.1 AWE AU^{-1} d^{-1}).

6.3.4. Weight gain of animals and village herd size

Mean liveweight gains (see Table 6.10) were significantly higher in the 1990 dry season than in the other two seasons ($P<0.05$). Mean values were quite similar for the three farm types. Differences between animal classes were not statistically different ($P>0.05$) either, although the means for calves and bulls were higher than those for heifers and cows. The total number of Animal Units (cattle+sheep+goats) in

Table 6.8. Least squares means (L.S. Mean) with standard error (S.E.) of amounts of dry matter (DM), crude protein (CP) and digestible organic matter (DOM) offered (g $LW^{-0.75}d^{-1}$).

Source of variation	n	DM		CP		DOM	
		L.S. Mean[1]	S.E.	L.S. Mean[1]	S.E.	L.S. Mean[1]	S.E.
Overall	219	86.3	2.8	9.1	0.4	43.7	1.5
Village :							
Putukrejo	119	90.9[a]	3.5	8.1[a]	0.5	45.3[a]	1.8
Kedungsalam	100	81.7[a]	4.3	10.1[b]	0.6	42.1[a]	2.3
Farm type[2] :							
O	108	95.8[a]	3.7	9.9[a]	0.5	48.5[a]	1.9
OS	60	71.7[b]	4.9	7.9[a]	0.6	36.0[b]	2.6
S	51	91.4[a]	5.6	9.4[a]	0.7	46.6[a]	2.9
Season :							
Dry'90	70	91.2[a]	4.6	9.1[a]	0.7	46.9[a]	2.4
Wet'91	84	92.6[a]	4.2	10.8[b]	0.6	45.6[a]	2.2
Dry'91	65	75.2[b]	4.9	6.6[c]	1.0	38.8[b]	2.6

[1] Means with different superscripts are significantly different ($P<0.05$)
[2] O: farms rearing owned cattle only; OS: farms rearing owned and shared cattle; S: farms rearing shared cattle only

Table 6.9. Least squares means of the amount of DM collected per hour (kg h^{-1}).

Forages	Putukrejo[1]	Kedungsalam[1]	Difference between villages[2]
Tree leaves	2.0[a]	4.3[a]	s
Grasses	4.5[b]	5.5[a]	ns
Sugarcane leaves	6.5[c]	-	-
Cassava leaves	4.9[c]	5.5[a]	ns
Rice straw	5.6[c]	3.7[a]	ns
Maize straw	9.0[d]	8.8[b]	ns

[1] Values followed by different superscripts in a column are significantly different ($P<0.05$)
[2] s: $P<0.05$; ns: $P>0.05$

Putukrejo was 1320 as compared to 2985 in Kedungsalam (see Table 6.11). In both villages cattle accounted for about 85% of the total.

Table 6.10. Least squares means (L.S. Mean) with standard error (S.E.) of cattle liveweight gain (kg d^{-1}).

Source of variation	n	Liveweight gain	
		L.S. Mean[1]	S.E.
Overall	66	0.154	0.049
Village:			
Putukrejo	25	0.134[a]	0.058
Kedungsalam	41	0.173[a]	0.064
Farm type[2]:			
O	36	0.146[a]	0.049
OS	23	0.112[a]	0.060
S	7	0.203[a]	0.111
Animals' class:			
Calves	5	0.341[a]	0.125
Cows	29	0.086[a]	0.056
Heifers	20	-0.003[a]	0.063
Bulls	12	0.191[a]	0.086
Season:			
Dry '90	20	0.291[a]	0.071
Wet '91	20	0.072[b]	0.065
Dry '91	20	0.098[b]	0.064

[1] Means with different superscripts are significantly different ($P<0.05$)
[2] O: farms rearing owned cattle only; OS: farms rearing owned and shared cattle; S: farms rearing shared cattle only

6.4. Discussion

6.4.1. Forage availability

The yields of maize leaves, rice straw and sugarcane tops found in this study were within the range of data for East Java given by Anonymous (1982), Ifar (1991), PLS (1981) and Sulistyo *et al.* (1992). The yield for cassava leaves found in this study is lower than the 1.8 t DM ha^{-1} given by Anonymous (1982) for Java or the 1.1 t DM ha^{-1} given by PLS (1981) for East Java. Apart from possible differences in soil fertility and crop management practices, the yield of cassava leaves at harvest in Putukrejo and Kedungsalam is reduced by the practice of picking leaves when plants are four months old or older, for use as a vegetable.

Apart from tops, sugarcane fields also produce sugarcane leaves and ratoon. This

Table 6.11. Number of ruminants.

Items	Putukrejo			Kedungsalam		
	Cattle	Goats	Sheep	Cattle	Goats	Sheep
% of households keeping	60.6	14.0	25.4	61.8	30.4	8.8
Average number of animals/household	1.95	2.68	2.60	1.92	2.58	3.50
Age distribution (% of total number)						
- mature	52.2	47.4	62.1	65.3	61.2	65.1
- medium	20.2	37.3	10.6	15.1	21.9	17.1
- young	27.5	15.3	27.3	19.6	16.8	17.8
Conversion factor						
- mature	1.20	0.23	0.20	1.09	0.24	0.21
- medium	0.96	0.18	0.15	0.99	0.18	0.15
- young	0.48	0.09	0.08	0.38	0.09	0.09
No. of Animal Units (AU)						
- mature	749	41	83	1905	260	95
- medium	232	26	11	400	70	18
- young	158	5	15	199	27	11
- all	1139	72	109	2504	357	124

is very important in Putukrejo. By producing the latter two forage types, sugarcane fields in Putukrejo provide forage throughout the year. Preston and Leng (1987) and Preston (1993) only mention cane tops and bagasse as by-products of sugarcane that can be used as a feed resource for ruminants. In Putukrejo, however, the leaves and ratoon form an important part of the feed resources during the season in which no tops are available. Bagasse is not available in the area.

Devendra (1990) commented on the difficulties of quantifying the contribution of shrubs and trees in forest and woodland to the availability of fodder. In various parts of the world, including Asia, statistical data are inadequate. The present study also showed that it is very difficult to quantify forage yields from shrubs and trees on non-agriculture areas, because they grow in both mono- and mixed cultures and on land owned by farmers and land owned by the Department of Forestry (*bongkoran* and forest). The forage can be harvested by the owner of the land as well as by others and harvesting is irregular, both in terms of time and methods. Due to this, errors of estimation for the amount of tree leaves can be expected, especially in Kedungsalam. This is also true for the availability of native grass and even crop residues in Kedungsalam, because of the large variation in the quality of land used for food crops in this village as compared to Putukrejo (Susilo, 1991; Widianto, personal communication). It can be expected that considerable areas of poorer land in Kedungsalam are used to grow food crops but are not included as such in the village records.

The concentration of CP and the organic matter digestibility (OMD) of forages available in Putukrejo and Kedungsalam are within the range reported for these feeds in the literature (Göhl, 1981). The combined results of quantities of different forages available and their digestibility and CP contents indicate considerable differences between the two villages. In Putukrejo, the tops, leaves and ratoon of sugarcane (all low in N/DOM) are a major fodder resource, which is absent or negligible in Kedungsalam. On the other hand, much larger amounts of gliricidia and cassava leaves (high N/DOM) are available in Kedungsalam. As said in Sub-section 6.3.3.1, farmers restrict the amount of cassava in the ration to avoid HCN-poisoning.

Differences in availability of forages between the two villages are related to differences in land use, resulting from the combined effect of land characteristics (deep soils in Putukrejo and shallow soils in Kedungsalam) and market opportunities. Although sugarcane was introduced in Kedungsalam before Putukrejo, it has since disappeared from this village; the farmers blame the lack of an adequate marketing system. On the other hand, an active and sizable lime burning industry has developed in Kedungsalam, stimulating the production of gliricidia.

The amounts of individual feeds and also the total amount available show a large seasonal variation and are also subject to longer term changes. In Kedungsalam, the growing interest of the Department of Forestry in the production of albizia has led to the opening up of natural forest and the presence of *tumpangsari* land where maize, cassava or upland paddy can be cultivated by farmers on a contract basis for three years. During this survey, about 120 ha of *tumpangsari* was found, i.e. 8% of the natural forest area. It can be expected, however, that this area will expand in the near future as more forest is cleared to grow albizia. During the first few years after clearing and planting of albizia, more crop residues will be available. At a later stage, probably after nine to ten years, the additional crop residues will gradually be replaced by native grass under albizia. Taking into consideration that the yield of native grass is about half that of crop residues, the amount of forage produced on the present *tumpangsari* area can be expected to decrease to half of the present amount or even less, six to nine years from now, especially if the effect of the closing albizia canopy is taken into account. Thus, in the near future the availability of forage in Kedungsalam may be subject to considerable fluctuations, not only because of annual differences in rainfall, but also depending on the rate at which the natural forest is cleared. It is uncertain whether farmers will continue to have access to the understorey grasses after the termination of their *tumpangsari* contract. Seymour and Rutherford (1993) mention that the Javanese forestry *tumpangsari* system gives farmers only temporary access to land. The custodial approach of the State Forest Corporation to forest management is characterized by treating villagers who enter forest areas for grazing or collecting forage as trespassers. This implies that farmers do not have secure access to these resources.

6.4.2. Access to feed resources

In Putukrejo, sugarcane forage is the major forage fed, especially in the dry season. In this season, sugarcane is harvested and a considerable amount of sugarcane tops is available. Farmers who do not grow sugarcane themselves, like the respondents in this study, have access to sugarcane forage by working as labourers in sugarcane fields. At least one member of each of the 9 respondent households in Putukrejo worked as a labourer in sugarcane cultivation. It is customary for sugarcane labourers in Putukrejo to have the right to take home the tops, ratoon or leaves they harvest. If the amount of the forage they harvest is larger than what they can carry and use themselves, their relatives may pick up the remainder. This custom, and the considerable amount of sugarcane available at the village level, makes farmers in Putukrejo less dependent on on-farm resources than farmers in Kedungsalam.

Farmers in Kedungsalam have larger numbers of gliricidia trees on-farm than farmers in Putukrejo. In addition, farmers in Kedungsalam have larger areas of *bongkoran* and *pekarangan* on which native grass and fruit and timber trees are grown. These differences in land use mean that farmers in Kedungsalam have more on-farm resources to feed their cattle than their colleagues in Putukrejo.

Access to cane forage is not restricted to regular labourers and their relatives. Any forage gatherer from within or outside the village boundary can obtain sugarcane forage by asking permision from the owner of the field or the labourer who is working there. Usually these forage gatherers must cut the cane from which they want the tops. So, although having the first right to use the sugarcane forage, the sugarcane labourers often share this forage with others. This practice is also found in the collection of rice, maize and cassava residues. In both villages, all those who help the owner to harvest a crop, are entitled to collect the residues. These practices of sharing forages represent an important community tradition of mutual help. If someone has problems in getting forage, for whatever reason, he or she can rely on help from others. This tradition also implies that farmers have to share their crop residues. So, having a larger farm and producing a large amount of crop residues does not necessarily mean that the farmer can maintain a larger herd.

6.4.3. Composition of rations

Farmers in both villages use a combination of feeds to compose rations. In the dry season, in both villages the digestibility of the rations fed was lower than that of the weighted mean of the forages produced (see data in Table 6.7 and Figure 6.4). In the wet season the reverse was true. For Putukrejo these differences can largely be attributed to a transfer of low quality rice straw from the wet season to the dry season, combined with the fact that a considerable part of the sugarcane tops (relatively high digestibility) produced in the dry season is not used in the village itself but collected by farmers from neighbouring villages. In Kedungsalam these changes in comparative digestibility of the rations fed and the forage produced are largely caused by a transfer of rice straw and maize leaves from the wet season to the dry season.

For the concentration of CP in the rations fed as compared to the mean of the forages produced, similar trends to those described above for OMD are observed for Kedungsalam: in the dry season lower in the ration fed than in the forage produced and vice versa in the wet season. In both dry and wet seasons the percentages of gliricidia in the rations fed were larger than in the forage available, but in the dry season this positive effect on the CP content of the ration fed was offset by the fact that they used less cassava than available. In Putukrejo the CP content tends to be higher in the ration fed than in the forage produced in the first two seasons (1990 dry season and 1991 wet season) but lower in the 1991 dry season. The latter is at least partly explained by the fact that farmers had to use considerable amounts of rice straw because there was a shortage of feed as a result of the drought.

6.4.4. Animal performance

The overall mean for liveweight gain (154 g $animal^{-1}d^{-1}$) was lower than would be expected on the basis of the average amount of DOM offered (43.7 g $LW^{-0.75}d^{-1}$). Under the asumption that 32 g DOM $LW^{-0.75}d^{-1}$ is needed for maintenance and 2.5 g DOM per g LWG, a weight gain of 294 g $AU^{-1}d^{-1}$ would be expected. One possible explanation is that animals did not eat all the feed offered, because of spoilage and selective consumption (Zemmelink, 1986[a]). A 9% lower intake of DOM than the 43.7 g $LW^{-0.75}d^{-1}$ indicated in Table 6.8 would already account for the discrepancy.

The seasonal differences in LWG did not in all cases correspond with the data for amounts of CP and DOM offered. Thus, whereas the amount of DOM offered was the same in the 1991 wet season as in the 1990 dry season, and the amount of CP was significantly higher, the LWG was significantly lower. On the other hand, the lower LWG in the 1991 dry season as compared to the 1990 dry season, corresponds with the significantly lower amounts of CP and DOM offered in 1991. The reason for the discrepancy between comparative values for the wet season is not clear. Factors which could be involved are that forages in the wet season are more contaminated with soil and, partly as a result of that, greater selection by animals, implying a larger difference between the amount offered and the amount actually consumed. Forages are commonly fed in troughs with slatted floors and this, together with the practice of sometimes leaving left overs in the trough from one day to another makes it extremely difficult to measure the amounts of feed actually eaten. In addition, the accuracy of estimates could be affected by the small number of farms and animals involved.

6.4.5. Total amounts of feed available and utilized

The estimated Animal Units in Putukrejo (1320) and Kedungsalam (2985) represent a total of 82 991 and 187 672 units metabolic weight, respectively. Combining these data with the average amounts of DM offered in the two villages as given in Table 6.8, gives the following estimates for the total amount of DM offered to animals in the period May 1990 - October 1991: 4074 t in Putukrejo and 8280 t in Kedungsalam or 64 and 81%, respectively of the amounts produced.

This suggests that even though farmers from Putukrejo as well as Kedungsalam crossed the village borders to collect forages, i.e. imported feed, both villages studied could be net exporters of feed. Field observations confirm that many farmers from neighbouring villages collect sugarcane forage in Putukrejo. However, when similar balances as the above were calculated for individual feeds, it was found that the estimated amount of gliricidia fed in Kedungsalam during the 1990 dry season was 2.6 times higher than the estimated amount produced. For the 1991 wet season this ratio was 1.9. Similar ratios were found for the amount of native grass+tree leaves fed and produced in Putukrejo: 3.2 for the 1990 dry season and 3.6 for the 1991 wet season. These ratios were even higher for gliricidia in Putukrejo: 8.8 and 7.1, respectively. The largest relative discrepancy was for elephant grass in Kedungsalam: amount fed 166 times higher than the estimated amount produced in the 1990 dry season and 7.1 times higher in the 1991 wet season.

It should be recalled here that the data on the composition of rations fed are based on a small number of farms (9 in Putukrejo and 9 in Kedungsalam) included in the Intensive Household Survey of the INRES project. With a view to research on multistorey cropping to be carried out by the INRES agronomist, one of the criteria households had to meet to be included in the survey was the possession of a home garden (*pekarangan*). It is therefore possible that the composition of rations fed on these farms is not typical for the whole village: the proportion of gliricidia is especially likely to have been overestimated. General observations in the village indicate that the amount of elephant grass used in Kedungsalam as a whole is also much less than that measured on the sample farms. In any case, the above discrepancies were not considered sufficient justification to adjust estimates of the total amount of feeds available in the villages, and the estimates given in Appendix 1 were used as a basis for model studies.

6.4.6. Concluding remarks

The data presented in this chapter indicate that farmers in both villages are confronted with a variety of feeds and large seasonal fluctuations. Farmers do not use the feeds indiscriminately. They mention labour constraints and differences in the time needed to collect different feeds (ease of collection) as one of the factors influencing their choice. Nevertheless, they are also well aware of differences in quality. Although the farms on which the composition of the ration was measured were not fully representative for the two villages, it was apparent that farmers tend to use the better quality feeds to feed their animals. That they restrict the amount of cassava leaves in the ration only confirms their awareness of quality (in the wider sense of the word). Rice straw and maize forage available in the wet season are only partly used in that season, but considerable quantities are stored and used in periods of scarcity. Seasonal excesses of perishable green feeds are collected by farmers from adjacent villages.

OPTIMUM UTILIZATION OF FEED RESOURCES

7

7.1. Introduction

The results presented in Chapter 6 indicate that the availability of feeds in Putukrejo and Kedungsalam is very complex. Not only the total quantity of feed but also the proportion of individual feeds varies from month to month, and hence so does the average quality in terms of digestibility and CP concentration. In both villages, any fixed herd size implies that farmers are confronted with either seasonal shortages of feed, or seasonal excesses, or both. As indicated in the preceding chapter, farmers apparently try to mitigate the effects of fluctuations in seasonal feed supply by carrying over feed from one season to another, especially rice straw and maize forage.

Model studies were used to arrive at quantitative estimates of (a) the effects of selective utilization of feeds, (b) the monthly variation in optimum herd size and (c) the optimum constant herd size for both villages, taking into account restrictions to the utilization of individual feeds and possible carrying over of feeds from one season to another. Finally, possible options for increasing animal production are discussed.

7.2. Methods

Calculations were done according to the JAVA programme (Zemmelink *et al.*, 1992; Zemmelink and Ifar, 1993). This programme was designed to calculate the effect of varying degrees of selection on (a) the number of animals that can be fed *ad libitum*, (b) the corresponding production in terms of liveweight gain per animal and (c) the combination of these two: the total production of the herd. An important feature of the programme is that it does not assume a fixed value for feed intake, but takes into account that voluntary intake is related to the quality of feed. The input data required is a feed table giving the amount and quality of each feed and its seasonal availability. The programme allows for a number of options to express the quality of feeds as well as different settings of parameter values for calculating animal production. For the sake of brevity, only those used for the present analysis are given below.

The JAVA programme is based on the principle that maximum animal production (in the restricted sense of meat or milk) is obtained when as little as possible of the feed is spent on maintenance, i.e. when animals are fed *ad libitum* and, if only part of the feed is used, the feeds giving the highest intake of metabolizable energy (IME) are selected first. The first step of the analysis is therefore to rank the feeds according to IME. This value is calculated in two steps. First, intake of organic matter (IOM) is calculated using the following equation, derived by Ketelaars and Tolkamp (1991) for sheep:

$$IOM = -42.78 + 2.3039*OMD - 0.0175*OMD^2 - 1.8872*N^2 + 0.2242*OMD*N \quad (1),$$

where IOM is expressed in g $kg^{-0.75}d^{-1}$ and both OMD (digestibility of organic matter) and N (nitrogen concentration in organic matter) as % (g/100g). The IOM calculated in this way for sheep is multiplied by an intake correction factor (1.333) to account for the higher average metabolism level of cattle as compared to sheep. After this, IOM is multiplied by OMD to arrive at IDOM (intake of digestible organic matter) and this is converted into IME, assuming that 1 g digestible organic matter (DOM) is equivalent to 15.8 kJ ME.

After ranking the feeds according to IME, the programme starts a stepwise procedure. In Step 1, a certain proportion (e.g. 1%, to be determined by the user) of the total amount of feed available is taken, in Step 2 the next 1% is added, etc. until all feeds are included. At each step, the programme calculates the following values:

(a) total amount of feed dry matter (DM) included;
(b) weighted mean of OMD and N;
(c) IOM, as described above;
(d) IDOM and IME, as described above;

and using these values it calculates:

(e) the number of animal units (AU) that can be fed *ad libitum*: in principle (a)/(c), but taking into account the definition of the animal unit, the period of time, and ash content of the feeds;
(f) production (mean liveweight gain, MLWG) per AU per day, and
(g) total liveweight production (TLWP): (e)*(f).

As in the preceding chapter one AU was defined as an animal weighing 250 kg, MLWG per AU per day (f) is calculated with the equation: $MLWG=(IME-ME_M)/b$, where ME_M represents the maintenance requirements and b the amount of ME needed per unit liveweight gain. In the present study values for ME_M and b were set at 512 kJ $kg^{-0.75}d^{-1}$ and 38.1 kJ g^{-1}, respectively.

In its basic setting, the JAVA programme lists (or plots) all data against the fraction of feed included in the ration as independent variable. Studies aimed at the calculation of constant optimum herd size (HS) under conditions of seasonal changes in feed supply require values to be calculated for predetermined herd sizes. In the present research, HS was varied in steps of 100 AU for such calculations. Normally, the programme works with a time step of one year. This can be divided into any (whole) number of seasons, but within a run, all time steps must be of equal size. For the present study a year was assumed to have 360 days, divided into 12 months of 30 days.

Unless indicated otherwise, the results presented below are based on the feed table for the period May 1990 - April 1991 (see Appendix 1). As observed in Chapter 6, this represents a year with about average rainfall and distribution. The estimates of forage yields for that period appear to be the most accurate.

7.3. Results

7.3.1. Effects of selective utilization of feeds

Table 7.1 gives the feeding value of individual feeds in terms of IME, calculated according to the methods described above, together with their proportion in the total amount of feed in Putukrejo and Kedungsalam (pooled for the year May 1990 - April 1991). Cassava leaves and gliricidia are clearly the outstanding feeds, allowing energy intake levels of 1.8 - 2.3 times maintenance. The sugarcane forages represent medium class materials (1.2 - 1.4 times maintenance), whereas native grass, maize leaves and elephant grass are all estimated to provide only a maintenance ration if fed on their own. Rice straw is clearly a sub-maintenance feed.

The solid lines in Figure 7.1A-F show the effect of varying degrees of selection of feeds by the farmer in Putukrejo. When, e.g. only the best 5% of the feeds, including all cassava leaves and gliricidia, and 20% of the sugarcane ratoon is used, a high quality ration (16.0% CP; 72.5% OMD) is obtained. As a result, IME (969 kJ $kg^{-0.75}d^{-1}$) and MLWG (754 g $AU^{-1}d^{-1}$) are also high. However, only 114 AU can be fed *ad libitum* with this small amount of feed. Therefore, TLWP (Figure 7.1F) is only 31 t y^{-1}. When more of the ratoon and subsequently also other feeds are included in the ration, the quality of the ration decreases and, consequently, also IME and MLWG per AU. However, the number of animals that can be kept increases more than proportionally because animals eat less of the lower quality feed. When 40% of all DM is used, 1158 AU can be kept. MLWG at this level of utilization is only 277 g $AU^{-1}d^{-1}$, but this sharp decrease in production per animal is more than compensated by the increase in HS, so that TLWP increases to 115 t y^{-1}.

The increase in TLWP is comparatively steep at the lower levels of utilization,

Table 7.1. Feeding value of individual forages.

Feed	Estimated IME ($kJ\ kg^{-0.75}d^{-1}$)	Proportion (%) of total DM (May 1990 - April 1991)	
		Putukrejo	Kedungsalam
Cassava leaves	1179	2.0	7.1
Gliricidia	912	1.4	10.5
Sugarcane ratoon	698	8.2	-
Sugarcane leaves	674	6.0	-
Sugarcane tops	603	40.6	-
Native grass	529	8.5	28.3
Maize leaves	508	11.3	40.1
Elephant grass	503	0.6	0.9
Rice straw	403	21.4	13.0

but becomes less steep at the higher levels. This is because at the lower levels, increases in utilization imply the addition of larger amounts of high-medium quality feeds (cassava leaves, gliricidia, and sugarcane forage), while at the higher ranges (58-78%) the poorer quality feeds native grass, maize leaves and elephant grass are added. Beyond 78% feed utilization, the decreasing MLWG per AU is no longer compensated by increasing HS. From that point onwards, low quality rice straw is included in the ration, leading to a sharper decrease in ration quality, IME and MLWG. Thus, whereas at 100% utilization of feeds 2976 AU can be fed *ad libitum*, maximum TLWP (160 $t\ y^{-1}$) is obtained when 2293 AU are kept, utilizing 78% of the feeds, i.e. all feeds except rice straw.

The dotted lines in Figure 7.1 show the responses for Kedungsalam. The situation in this village differs in two respects from that in Putukrejo: the estimated total amount of feed DM for the period May 1990 - April 1991 (7907 t) is 1.6 times higher than in Putukrejo (4967 t) and a much larger proportion of the total consists of high quality cassava leaves and gliricidia (18% versus <4%), while low quality rice straw amounts to 13% of the total as compared to 21% in Putukrejo. A major difference is the absence of sugarcane forages in Kedungsalam. As a result of these differences, at all levels of utilization the CP content of the ration is much higher than in Putukrejo, while OMD is higher up to 29% utilization and lower than for Putukrejo at higher levels of utilization. As a result, IME and MLWG at the lower levels of utilization are much higher than for Putukrejo. Beyond 70% utilization, the difference is small.

In Kedungsalam, a maximum of 4443 AU could be fed *ad libitum*, but again, maximum TLWP (246 $t\ y^{-1}$) is obtained by a smaller herd (3810 AU), utilizing 87% of the total feed DM. At all levels of feed utilization, TLWP is higher for

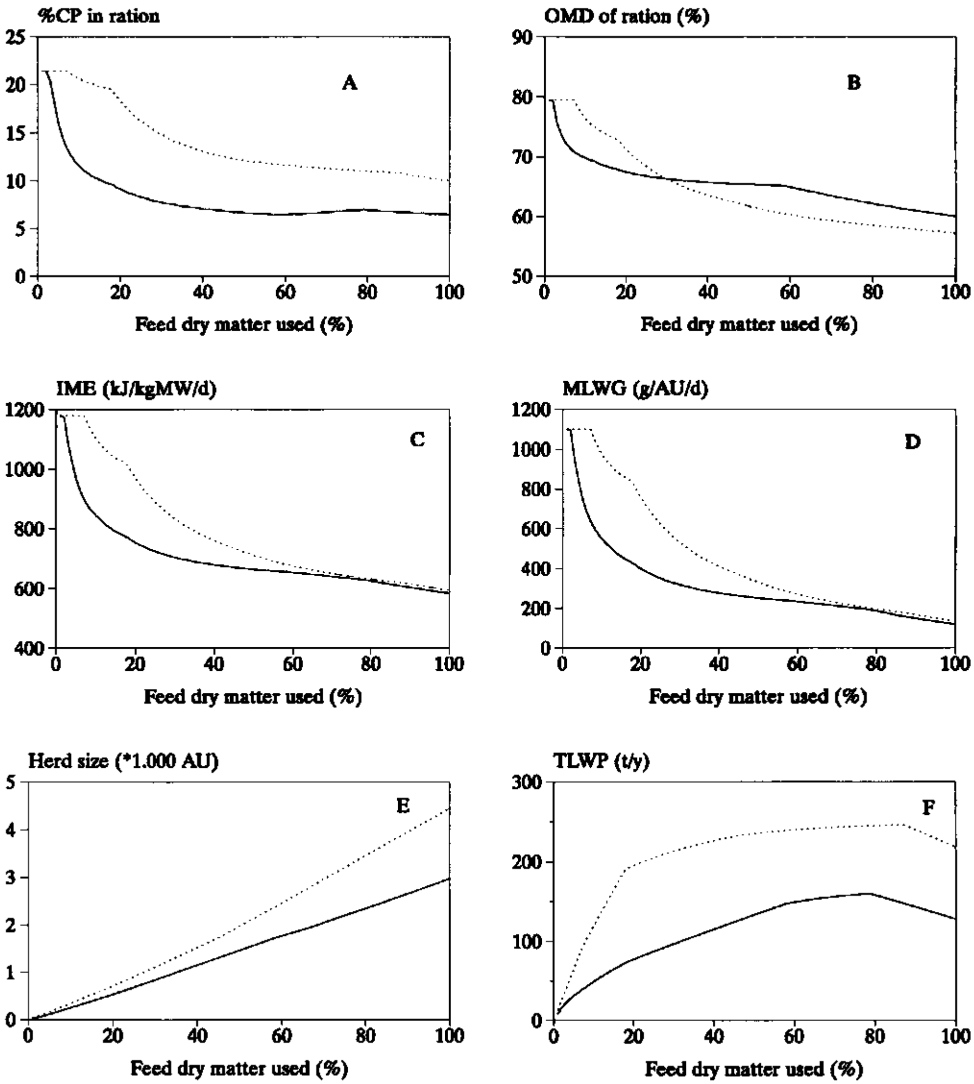

Figure 7.1. Effect of using various proportions of total feed dry matter on concentration of crude protein (A) and organic matter digestibility (B) of the ration, and the resulting intake of metabolizable energy (C), liveweight gain per animal (D), herd size (E) and total production of live weight (F) in Putukrejo (solid lines) and Kedungsalam (dotted lines).

Kedungsalam than for Putukrejo. For utilization levels higher than 70%, this is largely due to the larger total amount of feed and resulting larger HS. For lower levels of utilization this difference is due to a combination of a larger HS and higher MLWG.

Table 7.2a. Values of some production parameters if all available feeds in each month are used and if the use of the available feeds is optimized in Putukrejo.

Month	All forages used				Optimum use of feeds			
	IME	HS	MLWG	TLWP	% DM used	HS	MLWG	TLWP
1990								
May	617	583	173	3.0	100	583	173	3.0
June	609	3846	160	18.4	100	3846	160	18.4
July	663	3213	249	24.0	100	3213	249	24.0
August	637	3851	207	23.9	100	3851	207	23.9
September	616	3550	171	18.2	100	3550	171	18.2
October	629	2555	194	14.9	100	2555	194	14.9
November	653	1188	233	8.3	100	1188	233	8.3
December	527	2892	25	2.1	46	1244	246	9.2
1991								
January	515	4130	5	0.6	61	2445	111	8.2
February	596	2555	139	10.6	100	2555	139	10.6
March	495	4078	-28	-3.4	44	1703	148	7.6
April	499	3633	-21	-2.3	33	1087	281	9.1

Note: IME: Intake of metabolizable energy (kJ $kg^{-0.75}d^{-1}$); HS: Herdsize (AU); MLWG: Mean liveweight gain (g $AU^{-1}d^{-1}$); TLWP: Total liveweight production (t $month^{-1}$); %DM used: proportion of feed dry matter used

7.3.2. Effects of seasonal distribution

The results of calculations using monthly feed availability data are presented in Table 7.2. Whereas 2976 AU could be fed *ad libitum* in Putukrejo when the feeds were pooled for the year May 1990 - April 1991, this number varies from 583 in May 1990 to 4130 in January 1991. Similarly, whereas 4443 AU could be fed on the pooled feeds in Kedungsalam, the monthly values vary from 1446 (October 1990) to 11080 (January 1991). Furthermore, the quality of the ration (weighted mean for all feeds of %CP, OMD; see Figure 6.4) and, hence, IME when using all feeds, vary greatly between months. As a result, the calculated MLWG in the period May 1990 - April 1991 varies in Putukrejo from -28 g $AU^{-1}d^{-1}$ in March 1991 to 249 g $AU^{-1}d^{-1}$ in July 1990, and in Kedungsalam from 16 g $AU^{-1}d^{-1}$ in March 1991 to 471 g $AU^{-1}d^{-1}$ in August 1990. Whereas maximum monthly TLWP in Putukrejo would be obtained at 100% feed utilization in the months May-November 1990, and February 1991, in the

Table 7.2b. Values of some production parameters if all available feeds in each month are used and if the use of the available feeds is optimized in Kedungsalam.

Month	All forages used				Optimum use of feeds			
	IME	HS	MLWG	TLWP	% DM used	HS	MLWG	TLWP
1990								
May	560	3286	79	7.8	59	1779	254	13.5
June	720	1719	343	17.7	100	1719	343	17.7
July	727	5099	355	54.4	100	5099	355	54.4
August	797	2667	471	37.7	100	2667	471	37.7
September	700	1555	311	14.5	100	1555	311	14.5
October	633	1446	200	8.7	100	1446	200	8.7
November	664	1817	250	13.6	100	1817	250	13.6
December	615	2575	170	13.2	78	1930	264	15.3
1991								
January	531	11080	32	10.5	40	4150	113	14.1
February	540	9571	46	13.3	45	4065	114	13.9
March	522	8507	16	4.1	51	4129	113	14.0
April	556	4507	72	9.8	47	1882	343	19.4

Note: IME: Intake of metabolizable energy (kJ $kg^{-0.75}d^{-1}$); HS: Herdsize (AU); MLWG: Mean liveweight gain (g $AU^{-1}d^{-1}$); TLWP: Total liveweight production (t $month^{-1}$); %DM used: proportion of feed dry matter used

other 4 months maximum TLWP was obtained when only 33-61% of the available feeds were used. With HS adjusted to its optimum, the summed TLWP for these four months would be 34.1 t, whereas with a herd consuming all feeds this would be -3.0 t. The biggest difference was in March and April 1991, when utilizing all feeds caused the ration quality to be so poor that animals lost weight. For Kedungsalam, the estimated MLWG when all feeds are used is positive for all months. Nevertheless, values for the months May 1990 and January-April 1991 are < 100 g $AU^{-1}d^{-1}$). For these months, maximum TLWP was obtained when only 40-59% of the feeds were used. Also in December 1990, maximum TLWP was obtained when less than the total amount (78%) of the feeds was used.

With HS adjusted each month to the maximum that could be fed *ad libitum*, TLWP in the year May 1990 - April 1991 would be 118 t in Putukrejo and 205 t in Kedungsalam. When HS was adjusted monthly to obtain the maximum TLWP, these figures are 155 and 237 t, respectively. The latter two values are similar to the estimates given in Section 7.3.1 (160 and 246 t, respectively). Thus, according to these calculations, approximately the same TLWP could be obtained by either monthly adjustments of herd size or pooling all feeds for the whole year and combining this with the optimum constant HS of 2293 AU for Putukrejo and 3810 AU for Kedungsalam.

These estimates of optimal HS are much higher than the number of animals actually found (1320 and 2985 AU respectively). However, the two methods of overcoming the effects of seasonal feed supply mentioned are also unrealistic. Farmers cannot adjust the number of animals every month and, although they can carry over feeds from one month to another, this applies mainly to relatively dry materials such as maize stover and rice straw. Farmers in the area very rarely conserve fresh green materials. In addition, the above calculations are based on the assumption that there are no restrictions to the utilization of individual feeds. As mentioned in Chapter 6, however, farmers feed only limited amounts of cassava leaves, to avoid HCN poisoning. Therefore, an additional series of calculations was carried out, in which the assumptions made were based on observed farmers' practices as well as their comments about limitations to the utilization of cassava leaves. The results of these runs are presented in the next section.

7.3.3. Optimum herd size under conditions of seasonal feed supply

7.3.3.1. Putukrejo

Lines A in Figure 7.2 give the same values for annual TLWP and MLWG in Putukrejo as shown in Figure 7.1, but now plotted against the corresponding HS, and therefore show the effect of varying HS on animal production in this village when all feeds for the period May 1990 - April 1991 are pooled, i.e. when it is assumed that there are no seasonal variations in availability of feeds and no restrictions to the amount of individual feeds that could be included in the ration. As noted above, under those conditions maximum TLWP (160 t y^{-1}) is obtained with a herd of 2293 AU with a MLWG of 194 g $AU^{-1}d^{-1}$.

Lines B show the relation of TLWP and MLWG to HS where the latter is held constant through the year (at levels varying from 0 to 2800 AU, with steps of 100 AU), only using those feeds each month which are produced in that month. In that case, maximum TLWP is much lower (89 t y^{-1}) and obtained at a HS of 1100, with a MLWG of 226 g $AU^{-1}d^{-1}$. These values become even lower when, in accordance with farmers' practices, the amount of cassava leaves included in the ration is restricted. For construction of Lines C, it was assumed that the amount of cassava leaves should be limited to a maximum of 10% of the ration DM. In that case,

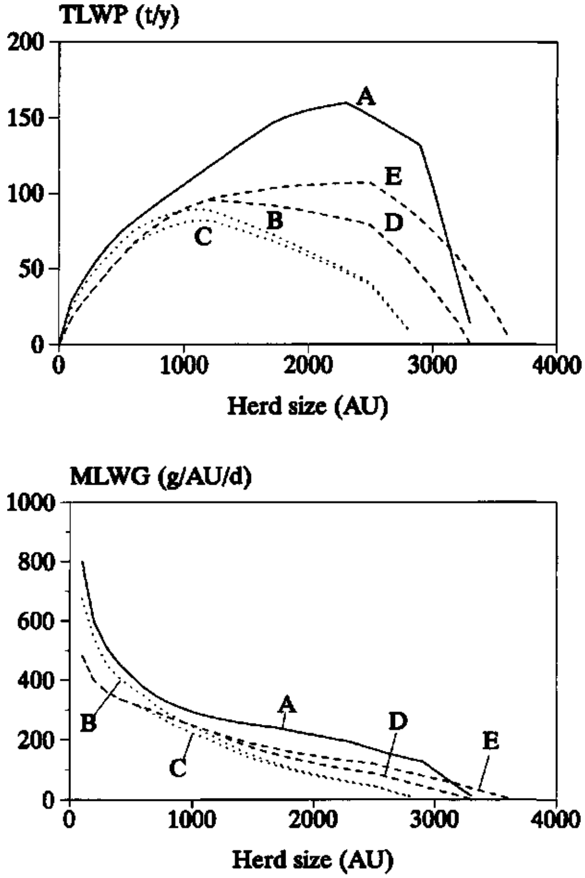

Figure 7.2. Effect of varying herd size on total liveweight production (TLWP) and mean liveweight gain per animal unit (MLWG) in Putukrejo for five conditions as described in the text.

maximum TLWP is reached at a marginally larger HS (1200 AU), but maximum TLWP itself decreases to 82 t y^{-1} and the corresponding MLWG to 189 g $AU^{-1}d^{-1}$.

Comparing Lines B and C with A indicates that the seasonality in feed production reduces the potential for animal production by nearly 50%. Whereas in most months a herd much larger than 1200 AU would be needed to take full advantage of the available feed resources, such a herd is not sensible because of feed shortages in other months. As indicated in Table 7.2, the most difficult months in the year May 1990 - April 1991 were May and November. Using only feeds produced in these months, in May only 583 AU could be fed *ad libitum* and in November 1188 AU, whereas in all other months this was 2555 AU or more.

Farmers supplemented their animals with rice straw in May, but not in November. Lines D in Figure 7.2 show the effect of feeding *ad libitum* supplementary rice straw in May, again with the restriction that no more than 10% cassava leaves should be included in the ration. Optimum HS, giving maximum TLWP was not changed by feeding extra rice straw in May, but (because weight loss in May was reduced) the MLWG for the whole year increased from 189 to 220 g $AU^{-1}d^{-1}$ and TLWP from 82 to 95 t y^{-1}. The effect of adding extra rice straw in November but not in May (maximum TLWP 83 t y^{-1} at HS=1200 AU; not shown in Figure 7.2) was minimal. On the other hand, maximum TLWP increased to 107 t y^{-1} when rice straw was added in both May and November and HS increased to 2400 AU (see Line E).

7.3.3.2. Kedungsalam

The results for Kedungsalam are summarized in Figure 7.3. Again, Lines A give the relation of TLWP and MLWG to HS, assuming that feeds can be pooled for the whole year and that there are no restrictions to the utilization of individual feeds. Similarly, Lines B give the effect of the monthly distribution of feeds compared with A and Lines C the additional effect of setting a maximum of 10% cassava leaves in the ration compared with B. The combined effect is similar to that in Putukrejo: a much lower maximum TLWP (152 instead of 246 t y^{-1}) at a much lower constant optimum HS (1500 instead of 3800 AU). In contrast to Putukrejo, however, much more of the reduction in maximum TLWP is attributable to the restriction on the use of cassava. A second difference between the two villages is that the optimum HS in Kedungsalam under the conditions of Lines C was much lower than the number of animals actually found in the village, whereas the difference was much smaller in Putukrejo. As can be seen in Figure 7.3, MLWG and TLWP would be negative if 3000 AU were kept under the conditions of Lines C. As can be derived from Table 7.2, this can be attributed to a shortage of feed in the months of June and August-December 1990. Field observations indicate that the shortage of feed in the lean months is covered by stored maize forage and rice straw. In the other six months, according to the model calculations a herd of 3000 AU gives an excess of 2401 t maize stover (78% of the total produced in those months), 28 t elephant grass (70%) and 616 t rice straw (66%). These figures are strictly hypothetical because the programme assumes that no maize leaves are used until all the native grass has been used up and no elephant grass until all maize leaves have been used up. In practice, of course, this is not the case. As may be seen in Table 7.1, however, there is very little difference in the feeding value of these three feeds. Therefore, the results of calculations are hardly affected by the strict order or feed selection in the calculation programme.

Using half of the calculated excess of maize leaves to replace native grass would

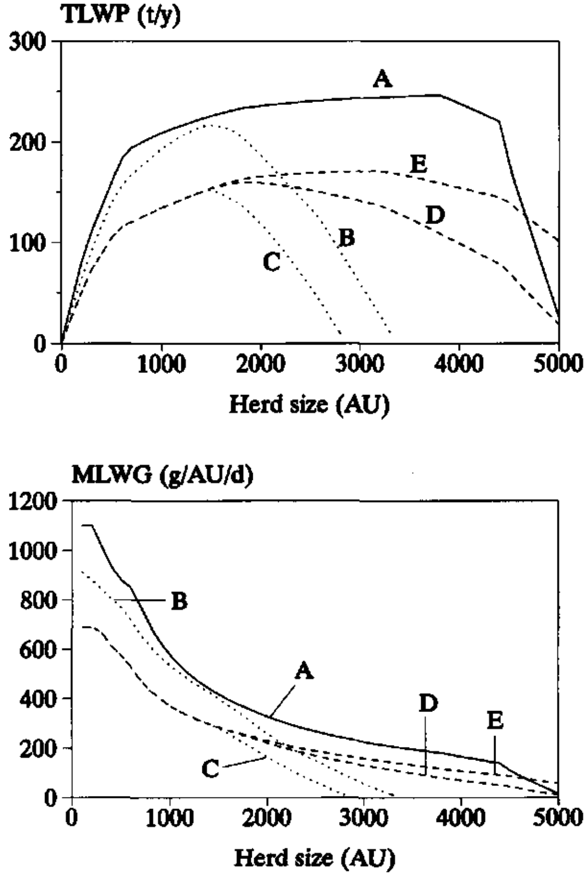

Figure 7.3. Effect of varying herd size on total liveweight production (TLWP) and mean liveweight gain per animal unit (MLWG) in Kedungsalam for five conditions as described in the text.

still give an excess of 1200 t. Combined with the 616 t of rice straw, this is more than sufficient to cover the deficiency of feed in the lean months, even for a herd size well above 3000 AU.

Lines D in Figure 7.3 give the relation of TLWP and MLWG to HS if animals are supplemented with *ad libitum* rice straw in the six months of feed shortage and Lines E show the relation if animals are supplemented with maize leaves. In the first case maximum TLWP is 160 t y^{-1} and reached at a herd size of 1900 AU with a MLWG of 234 g $AU^{-1}d^{-1}$; in the second case, maximum TLWP=171 t y^{-1} at HS=3200 AU and MLWG=148 g $AU^{-1}d^{-1}$. If the response lines D and E are weighted in a ratio 1:2, a maximum TLWP of 164 t y^{-1} is reached at HS=2300

(MLWG=197 g $AU^{-1}d^{-1}$); for a herd size of 3000 AU, TLWP would be only slightly lower (161 t y^{-1}) and MLWG 149 g $AU^{-1}d^{-1}$.

7.3.4. Prospects for increasing animal production

7.3.4.1. Putukrejo

As indicated in Sub-section 7.3.3.1, farmers in Putukrejo supplemented animals with rice straw in May but not in November. The model calculations confirm that when a choice has to be made between feeding supplementary straw in May or November, priority should be given to supplementation in May. On the other hand, the calculations also suggest that a similar extra increase in TLWP could be obtained by feeding rice straw in both May and November. There is, however, an essential difference in the manner in which the two increases in TLWP are realized. The increase of 13 t as a result of adding straw in May was produced by the same herd, in other words was the result of a higher MLWG per animal. On the other hand, the extra increase of 12 t as a result of feeding straw not only in May but also in November, resulted from doubling HS. This could be considered as an extra benefit because of increased intangible benefits and increased production of manure (see Chapter 5). Both of these are highly valued by the farmers. From this it seems logical to infer that, in accordance with Section 1.3, farmers in Putukrejo would keep a larger herd than actually found in the village (see also Zemmelink *et al.*, 1992). However, the fact that the extra 12 t TLWP can only be realized if HS is doubled also means that the MLWG decreases from 220 g $AU^{-1}d^{-1}$ to 124 g $AU^{-1}d^{-1}$, implying that the average feeding level of all animals falls from 1.26 to 1.15 times maintenance.

The calculation model does not distinguish between classes of animals. As reported in Chapter 5, however, 68% of the live weight is produced by calves, and farmers mention late first calving of heifers and long calving intervals as major problems. These problems are undoubtedly (at least partly) related to the low overall feeding level causing slow growth of heifers and considerable weight losses of lactating cows (see Section 5.3.1). The combined data on model calculations and weight changes of lactating cows indicate that the overall feeding level in Putukrejo is already so low that keeping more animals to increase the intangible benefits would be counterproductive. If the feeding level were further reduced, increased fertility problems could well lead to fewer calves and hence would interfere with one of the most important objectives of the farmer.

In addition, the calculations presented above were based on the feed supply in a year with favourable total rainfall and distribution. As shown in Figure 7.4, the

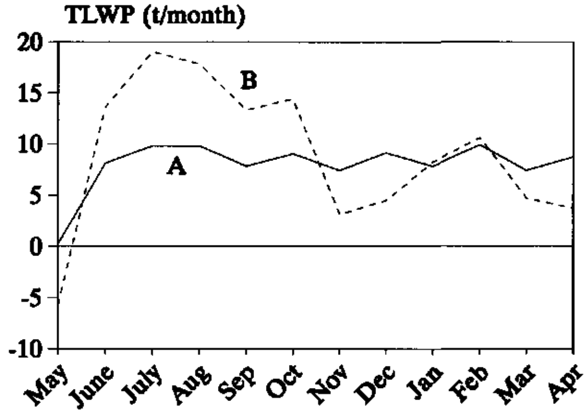

Figure 7.4. Predicted monthly total liveweight production (TLWP) in Putukrejo for a herd of 1200 Animal Units combined with feeding of supplementary rice straw in May (A) and for a herd of 2400 Animal Units combined with feeding of supplementary rice straw in May and November (B).

advantage of feeding extra rice straw not only in May, but also in November and combining that with a HS of 2400 instead of 1200, is entirely due to increased estimated production in the months June-October, i.e. the dry season when a large amount of sugarcane tops was available. For November, December, March and April, the estimated TLWP is lower with a HS of 2400 instead of 1200, because too much low quality feed has to be included in the ration to feed such a large herd.

As reported in Chapter 2, the limestone area has to cope with frequent droughts. One such drought occurred in 1991. As a result, the yield of sugarcane tops was much lower than in 1990. In most months of the 1991 dry season, the amount of feed produced was still sufficient to feed a herd of more than 1200 AU. However, the large excess of cane tops in 1990 was collected by farmers from neighbouring villages. These farmers also came in 1991 and, even with a herd of 1200 AU, this resulted in a shortage of feed in Putukrejo itself. Towards the end of the year, when rains still failed, the shortage of feed became so critical that farmers were forced to purchase large amounts of rice straw and, in many cases, pay for this by selling or sharing their animals (see Chapter 3). With a HS > 1200 AU, the problems of feed shortage and related economic risks would only have been greater.

The above analysis strongly suggests that farmers in Putukrejo use their feed resources quite efficiently and that it will be difficult to increase animal production in the village without increasing feed resources. Elephant grass and gliricidia have been introduced to increase these resources. However, there is a lack of fertile land available for elephant grass, and if grown on roadsides and the like, the yields of this plant are low. Moreover, under the local conditions it produces a forage of similar quality to native grass and maize forage, and mainly in the period of the year when these feeds are also available in relatively large amounts.

Given that most of the feeds in Putukrejo have a low N/energy ratio, it seems that considerable advantages could be obtained from growing more gliricidia than at present. The results of simulation runs with the same settings as for Lines D and E in Figure 7.2, but with 8 times more gliricidia, are shown in Figure 7.5 (Lines F and G, respectively). For easy comparison, Lines D and E are also given again. With extra rice straw only given in May, optimal HS increased by a factor 1.33 from 1200 to 1600 as a result of adding extra gliricidia (compare Lines D and F). But due to the addition of gliricidia the maximum TLWP increased by a factor of 1.75 (from 95 to 168 t y^{-1}), implying that MLWG rose from 220 to 292 g $AU^{-1}d^{-1}$. Hence, adding gliricidia not only increased the optimum HS and TLWP, but also increased the MLWG per animal. This may have the extra beneficial effect of improved fertility. The comparison of Lines E and G leads to similar observations.

An eightfold increase in the amount of gliricidia may well be unrealistic. The calculated effects are, however, in agreement with the popularity of this crop and suggest that planting more gliricidia should be encouraged as it benefits animal production too. An alternative would be to use other feeds with a high protein (N) content, such as oilseed cakes. However, these would have to be imported from industrial centres at considerable distance from the village, are only available in limited quantities in East Java and are preferably used for monogastric animals.

7.3.4.2. Kedungsalam

Much of what was said above, also applies to Kedungsalam. The results of model calculations suggest that for this village too the herd size is well adapted to present conditions and that available feed resources are used quite efficiently. Lines F and G in Figure 7.6 illustrate the effect of doubling the amount of gliricidia as compared to Lines D and E from Figure 7.3. Even though the amount of gliricidia used in Kedungsalam is already much greater, and the available feed resources richer in N, model calculations suggest that here too livestock production could be increased by adding more gliricidia.

7.4. Discussion

As is true for any model, the calculation model used in the present study represents a strongly simplified description of reality. A large number of the factors known to

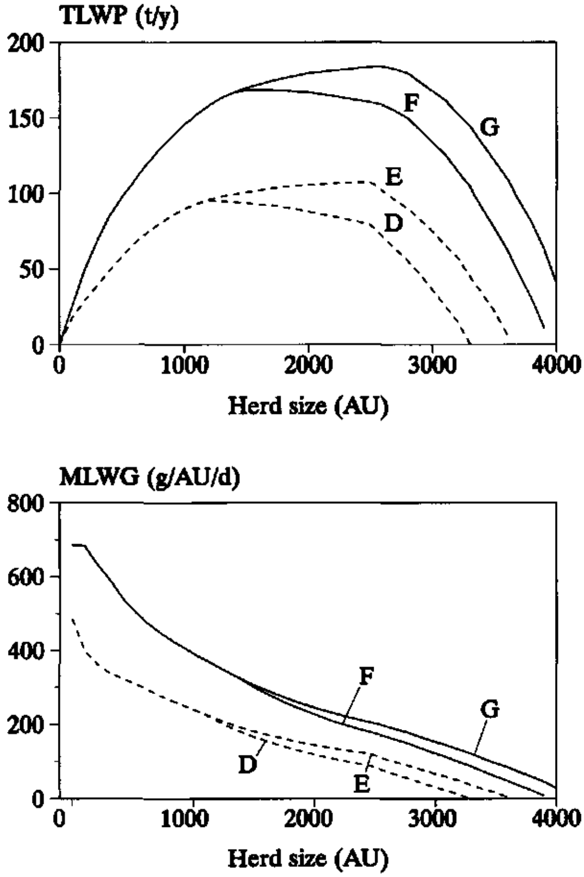

Figure 7.5. Effect of increasing the amount of gliricidia in Putukrejo by a factor 8 on total liveweight production (TLWP) and mean liveweight gain per Animal Unit (MLWG) (For further explanation see text).

affect the productivity of livestock, such as health status and genetic characteristics of the animals, are not included. The same holds true for the entire complex of socio-economic factors. In the above calculations it was assumed that farmers always select feeds according to their feeding value expressed in IME. In practice, they may deviate from this because of differences in ease of collection as discussed in Chapter 6, the fact that feeds are not evenly distributed over the area, and daily changes in time available for feed collection. On the other hand, it was assumed that there is no variation in the quality of each feed class, while in reality for instance the digestibility of maize stover with an estimated mean value of 53.5% may vary from less than 50% to 60%. Farmers surely recognize these differences in quality and this can have major

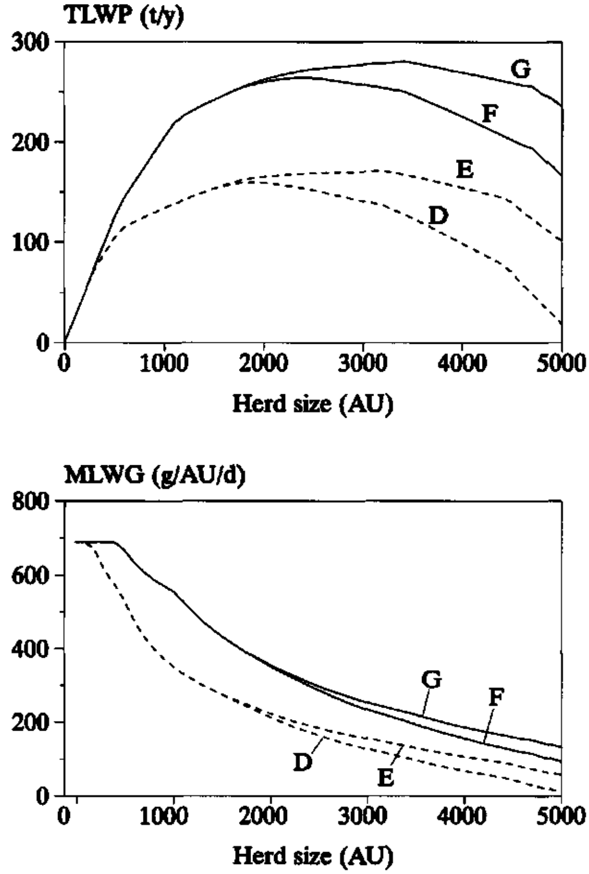

Figure 7.6. Effect of doubling the amount of gliricidia in Kedungsalam on total liveweight production (TLWP) and mean liveweight gain per Animal Unit (MLWG) (For further explanation see text).

effects on the actual performance of animals as well as on the results of model calculations, as discussed by Zemmelink *et al.* (1992).

In addition, the model works with standard animal units and does not distinguish between calves, pregnant and non-pregnant cows, heifers and bulls, and without considering the possible effects of a differentiated feed allocation. The only form of physical production recognized is liveweight gain of a standard animal unit. The estimation of liveweight gain starts with the estimation of feed intake, using a relationship between intake of feed and its N content and digestibility. The equation is based on data for a large variety of feeds. This gives a firm basis for the overall relationship, but also ignores possible differences between individual feeds with the same OMD and N content. After calculating intake by sheep, a fixed intake correction factor is used to arrive at estimates for cattle and similarly, liveweight gain is estimated by using fixed values for the requirements for maintenance and production expressed in metabolizable energy. Combined small changes in parameter values can have large effects on the results of calculations. This applies particularly to the intake correction factor.

The parameter values used in the present study are the same as those used in the study by Zemmelink *et al.* (1992) where the feed table for the whole province of East Java was the input for the programme. In that study calculated values for optimum herd size and corresponding productivity of animals, as well as the optimal degree of forage utilization, corresponded well with actual data according to national statistics. Using the feed table for the whole province implies, however, that all local (and even regional) differences were ignored. Moreover, the seasonal distribution of feeds was also ignored. The present study is the first in which the programme was used to model the situation in specific villages, with different feed tables, and incorporating the effect of seasonal availability of individual feeds. In addition, data on the amounts and composition of feeds were based on actual measurements rather than on statistical data and mean values derived from the literature.

The predicted liveweight gain of animals ranged from <0 to >1000 g $AU^{-1}d^{-1}$ depending on the assumptions made and herd size. The predicted values for assumptions most closely reflecting actual feeding practices (Line D in Figure 7.2 for Putukrejo; Lines D and E in Figure 7.3 for Kedungsalam) and HS equal to that found in the field survey are 199 g $AU^{-1}d^{-1}$ for Putukrejo and between 131 and 159 g $AU^{-1}d^{-1}$ (with a mean of 150 g $AU^{-1}d^{-1}$ if weighted 1:2) for Kedungsalam. The mean liveweight gain measured in the field during the same period is 182 g $animal^{-1}d^{-1}$ with a standard error of approximately 50 g $animal^{-1}d^{-1}$ (see Table 6.10). Thus, whereas the total range of predicted values is as large as could be expected, predicted values for actual conditions deviate less than one standard error from the value measured in the field. The discrepancy between predicted and actual values is remarkably small too when measured in absolute terms. This suggests that even though many factors affecting the day-to-day feeding practices and differences between classes of animals are ignored in the simulation programme, predictions for overall herd performance are reasonably accurate.

On that basis then, it may be concluded that farmers in both Putukrejo and Kedungsalam adapt feeding practices and herd size remarkably well to the resources at their disposal. The results of calculations do not on any point suggest that on the basis of the present feed resources a higher production could be obtained either by changing herd size or present practices of feed carry-overs from one season to another, unless farmers could increase the proportion of cassava leaves in the ration.

Apart from that, the only way to increase animal production is to improve the feed resource base, i.e increase the amount of higher quality feeds such as gliricidia. Hegarty *et al.* (1986) and Brewbaker (1986) reported on problems of unpalatability of gliricidia, but farmers in Putukrejo and Kedungsalam did not mention this. Neither did they mention any toxicity problems. In addition to its value as feed, gliricidia may also help to avoid soil erosion and is an important source of firewood. Planting more of it in places where it does not interfere with the production of food crops may therefore be recommended.

GENERAL DISCUSSION 8

8.1. Role of ruminants in the farming system

Farmers in the upland areas in Java engage in several activities, in response to their physical conditions, resource endowment and socio-economic needs (Sabrani *et al.*, 1989). Cropping is the farmers' primary activity to produce food for home consumption and sale. The principal determinants of crop production, i.e. soil quality, topography and land distribution differ between and within villages. The rainfall pattern also varies between years. This large variability is common for upland areas in East Java and other South-East Asian regions (Kepas, 1985; Devendra, 1993[a]; Escap, 1994) and results in cropping systems and land use differing between villages. The two villages studied, Putukrejo and Kedungsalam which are only 20 km apart, were selected on the basis of differences in land use. Putukrejo is situated in a rather flat area along the crest of the mountain range. Although affected by erosion, not all the topsoil has been removed, except on steep slopes. Sugarcane is grown on the flatter areas and wet rice is cultivated on the valley bottoms. There is hardly any forest. Kedungsalam is located on gentle to steep crests and ridges. More than half of the total area is covered by forest or *bongkoran* (fallow land) and agricultural land use is dominated by agroforestry. In both villages, farmers cultivate maize and cassava for subsistence.

On average, crops contributed 51% to farm household income in the two villages. Farmers can supplement income from crops by keeping ruminants or through non-agriculture or off-farm work. Engagement in a variety of farming and non-agriculture and off-farm activities is a common strategy of poor farm households. Complementary activities may reduce the variability of income and employment and hence, improve liquidity and reduce the economic risks of the farm household (Montgomery, 1981; White, 1981; Sabrani *et al.*, 1989). Similar to other upland areas in Java (Palte, 1989; Kepas, 1985) and in South-East Asia in general (Devendra, 1993[a]), ruminants are basically kept by farmers to increase the added value of non-marketable crop residues and native grass by converting them into products that are tangible (live weight, manure and draught power) or intangible (insurance and financing). Cattle are the prefered ruminant as they fetch a high cash price at sale.

Farmers who lack the capital to purchase cattle can obtain animals through sharing arrangements. Such systems are common in Javanese agriculture (Sabrani and Knipscheer, 1982). The prevalence of sharing and the method of dividing the profit between owner and sharer differs between villages. Differences in the distribution of shared cattle are related to land quality and the resulting land use system. Because prosperous cane farmers in Putukrejo invest in cattle, more animals were available in this village. Consequently, small farmers in this village had easier access to cattle for sharing than farmers in Kedungsalam (Chapter 3). The cattle sharing system also plays a role in maintaining herd size in drought periods when forages are in short supply. Farmers, who had difficulty in finding forage, especially those in Putukrejo, obtained money to purchase rice straw by selling their cattle to the better-off farmers while retaining them on the farm as shared animals.

Live weight accumulated in the herd is the most important production parameter because other benefits (cash income, finance and insurance) which are relevant for sustaining the farm household system are closely related to it. In Putukrejo and Kedungsalam, farmers rank the production of progeny much higher than the liveweight gain of older animals (Table 3.1). This agrees with the finding that 75% of the income from liveweight production came from the growth of calves. Calves are therefore the key to the liveweight accumulation process. Whether shared or own cows are kept, the progeny provide the farmer with an additional tradable asset. Even when forage is in short supply, cows can survive and produce milk for their calves by mobilizing their body reserves. Seasonality of forage supply, in terms of quality and quantity, may lead to intermittent growth of the cows but not the suckling calves. At present, the average production index of cattle in the two villages studied is 0.16 i.e. the live weight produced per farm per year is 16% of the average live weight of the herd.

Because calves are the major contributors to liveweight production, there are at least two aspects that need attention: reproduction and early growth. With regard to reproduction, apart from long calving intervals (>30 months), farmers complained about the late maturity of the heifers (first oestrus at three to four years of age). Retarded early growth is not seen as a problem by farmers. However, nearly all calves were infected with *Toxocara vitulorum* (Cornelissen, 1991; Ifar and Trisunuwati, 1992), which is known to retard early growth of calves in the tropics (Izaks, 1981; Shanmuhalungam, 1956). Enyinihi (1969) demonstrated that *Toxocara* infection resulted in reduced appetite and increased loss of protein in the faeces of infected calves while the animals use their fat reserves to cover energy demands. Treatment with anthelmintics had a beneficial effect on the growth of animals up to the age of 3.5 years.

Farmers find that artificial fertilizers are most effective when combined with farmyard manure (FYM). This is in line with the observations of Palte (1989) in the upland area in Central Java and Edmundson and Edmundson (1983) in other villages in the limestone area of South Malang, who found that manuring is necessary for crop farming in that area. The latter authors found that farmers applied half a ton of dry manure per ha per year. In the farmers perception, manure is as relevant as the production of progeny (Chapter 3). On that basis, one would expect that income from manure could be as high as income from liveweight (progeny) production. However, the income analysis showed that income from manure is only one-quarter of that from liveweight production. The calculated income from manure might be too low because only the major nutrients (N, P, K) of the manure were accounted for and manure supplies organic matter and micro minerals too. Manure also has a financing value as, without it, farmers need to purchase more 'expensive' inorganic fertilizers to secure crop production. Manure is not traded. This indicates that farmers value manure for their own use and that the amounts produced are not in excess of what is needed. The effect of manure application on crop production at farm level could not be fully evaluated because its effect depends on previous levels and methods of manure application, and the long-term effects on soil organic matter and soil structure. High levels of manure application (10 t of air-dry FYM ha^{-1}; Widianto, 1993) have been found to improve production of cassava and maize quite substantially (24% increase in fresh cassava roots and a 50% increase in maize cobs). This level of application is, however, far above the manure producing capacity of the present herd (1.2 t DM ha^{-1} y^{-1} $farm^{-1}$). Thus, herd size limits any increase in crop production that might be obtained through using more manure. Farmers maximize the effect of the limited amounts of manure by putting it in the hole in which a seed or cutting is planted.

Most farmers assign a low rank to the value of cattle for land cultivation (Table 3.1). In the village with larger areas of poor quality soil (Kedungsalam), 50% of the farmers gave no priority at all to keeping cattle for draught purposes. The income analysis also showed a low added value from using cattle for land preparation. Farmers will only use cattle for land preparation if land use, land characteristics and weather allow them to do so (Chapter 4). Substitutes for manure must be purchased, whereas more intensive use of manual labour for hoeing can be substituted for ploughing with cattle. This might explain why resource-poor farmers rank manure higher than the draught potential of cattle.

The live weight accumulated in the herd represents capital that can be used when cash is needed to finance items neccessary for the farm household's prosperity. Therefore, farmers also see their cattle as savings. A similar term is used by various authors e.g. Tillman (1981), Suradisastra (1983), Palte (1989) and Atmadilaga (1992), to describe the role of ruminants for small farmers in upland as well as lowland communities in Java and South-East Asia in general. In this study, the saving function is considered as an intangible product, comprising finance and insurance benefits. The financing benefits include saving on the transaction costs charged by formal or informal agents when farmers need credit. Animals may be disposed of as and when required to cover unexpected expenditure. So they represent insurance for which a premium has to be paid under advanced insurance market systems. Bosman and Moll (1995) found that the intangible products of goats in South-Western Nigeria were four times higher than the value added. In Putukrejo and Kedungsalam, the estimated value of intangible products from cattle keeping is close to one-third of the total added value obtained from the physical products (Chapter 5). The value of intangible products is 40% of the contribution of accumulation of live weight only. This is in agreement with the ranking of objectives by farmers who rank progeny production (the main component of liveweight production) above saving (Table 3.1). The rationale lies in the fact that increase in live weight, either from progeny or growth of older animals increases the selling value of the herd and thus also its financing and insurance benefits. Although farmers assigned a low rank to saving, the importance of intangible products certainly cannot be ignored. In many cases farmers were able to purchase or rent more land, improve their houses and meet family obligations as a result of the financing and insurance role of cattle. At a realistic return to capital (6%), the return from physical products of cattle production (Rp. 943 d^{-1}) is well below the average labour wages in the area (Rp. 1500). However, if the intangible benefits derived from the insurance and finance functions of cattle are added, the income from cattle reaches a level that is more in line with other income-generating activities, but still below the income of cattle fattening suggested by the Department of Animal Production of East Java (Rp. 2000 d^{-1}, Anonymous (1994)). Nevertheless, maintaining two cattle in Putukrejo and Kedungsalam secures employment for about 200 mandays per year in a socio-economic environment with low employment opportunities.

The objectives in research and development programmes should be set in relation to all benefits of livestock keeping. Up to now research aimed at improving livestock keeping is generally focused on physical production. Whereas the additional roles of livestock, such as being a living savings account and an insurance against unforeseen events, are only described in qualitative terms (Waters-Bayer and Bayer, 1992; Branckaert, 1993; Scoones, 1992). An exclusive focus on tangible benefits is too narrow to capture the role of livestock in farming systems operating in an economic environment characterised by poorly functioning or absent markets for financing and insurance (Bosman and Moll, 1995). The benefits of livestock in physical production, financing and insurance result in the livestock keeper having multiple, possibly conflicting, goals. Selling an animal for financing purposes may negatively affect the (re)productive performance of the herd and will certainly reduce the basis for insurance, the herd value (Moll, personal communication). To optimise the benefits of livestock, the livestock keeper must therefore balance conflicting goals of the animal system within the context of the farm system and the socio-economic environment. The multiple goals of cattle keeping may make it difficult to introduce technologies aimed at increasing biological production.

8.2. Forage resources and utilization

In common with many other areas in South-East Asia (de Boer, 1982; Moog, 1985; Udo *et al.*, 1992), forage resources in the limestone area of South Malang differ between and within villages, evolving from the diversity in land characteristics, market opportunities and the related land use and cropping systems. In Putukrejo, the tops, leaves and ratoon of sugarcane (all relatively low N/DOM ratio) are a major fodder resource, but this forage is hardly available in Kedungsalam. On the other hand, a much larger amount of gliricidia and cassava leaves (relatively high N/DOM ratio) is available in Kedungsalam. The ongoing changes in land use tend towards the intensification of food and cash crop production. This trend is stimulated by government projects on soil conservation and reduction of poverty (Section 1.1.2). Sihite and Uno (1991), for example, described a government programme to introduce cocoa in areas between Putukrejo and Kedungsalam that aims to boost farmers' income. Such changes in land use may lead to decreased production of green feeds. A similar trend was noted by Mahadevan and Devendra (1985) for most of the crop-livestock production areas in South-East Asia.

As is common in South-East Asia (de Boer, 1982; Moog, 1985; Atmadilaga, 1992; Udo *et al.*, 1992) farmers in South Malang practise cut- and carry-feeding and collect forages from various sources. Farms are small and the land is primarily used for the production of food and cash crops. Feeds from the own farm include crop residues (mainly maize and rice straw), grass and tree leaves (especially gliricidia). This is supplemented with significant amounts of feed from communal areas (roadsides, forests) and from other farms. The amount of feed collected off-farm varies, depending on the cropping pattern and distribution of land and animals. In one of the villages (Putukrejo), farmers included in this study obtained nearly three quarters of their feeds from outside their own farm. In a year with normal rainfall (May 1990 - April 1991) an excess of sugarcane tops in Putukrejo was available for farmers in adjacent villages, but farmers had to import rice straw from the lowland area when availability of feed in the village decreased as a result of drought in 1991.

There was only a very weak relation between the number of animals reared and the labour force per household. This could be expected, because households have numerous options to utilize the labour force they have. Nevertheless, the distribution of forages between livestock rearers seems to be largely determined by labour. Farmers who farm more arable land have larger amounts of crop residues, but much of this is collected by labourers who help harvest the crop. This privilege is not restricted to paid labourers. Any person who happens to pass by may collect crop residues provided they help with the harvest. At first sight, this implies a loss of feed resources for the owner of the crop. However, crop residues such as maize leaves and rice straw become available in relatively large amounts in a short period of time. Even if the owner of the crop has livestock himself, he cannot possibly feed these residues at the rate at which they are harvested. So, they must either be used by others or stored. These materials are indeed stored, but because they are wet and must be dried to avoid spoilage, this too requires much labour. Distribution of crop residues between those who help with the harvest is an important means to avoid waste due to spoilage. The same applies to sugarcane tops. Even though the cane harvest extends over a period of several months, individual fields are harvested in a short time. Labourers participating in the harvest are drawn not only from Putukrejo but also from adjacent villages. As a result, even in the year with an overall shortage of feed (1991), a large part of the cane tops was used by cattle rearers in adjacent villages. Thus, the distribution of crops residues is largely determined by the division of work at crop harvest. Native grass on roadsides, marginal land and forest areas is a communal resource and, naturally, the amount of these feeds collected by individual households also depends on the labour input. The relation with labour is also apparent from the selection criteria for sharers (see Chapter 3).

In farming systems studies, crops and livestock are often considered as two components (sub-systems) of an integrated crop-livestock production system (see e.g. Fresco and Westphal, 1988; Schiere, 1995). Both, the high degree of transfer of crop residues from one farm (or even village) to another, and the importance of feeds from communal areas imply, however, that at the household level, the boundaries of natural resources for the livestock production system are very different from those of the crop production system. Unlike crop production, forage production is not confined within a farm or even village boundary.

Farmers in Putukrejo and Kedungsalam are confronted with large seasonal and annual variations in feed supply. These variations are related to the differences in land quality and land use. In the year with normal rainfall (May 1990 - April 1991) the situation in Putukrejo was characterized by relatively short periods of below-average feed supply, while that in Kedungsalam was characterized by relatively short periods when the amount of feed was much higher than average. On the other hand, the drought of 1991 had a much more pronounced effect in Putukrejo than in Kedungsalam, because the former village relies heavily on cane tops, whereas the resources in Kedungsalam are more diverse, including a considerable area of forest. Contrary to what is often suggested, in the year with normal rainfall, the performance of animals was slightly better in the dry season than in the wet season (see Table 6.10). In Putukrejo this may be largely attributed to the availability of large amounts of cane tops in the 1990 dry season. In both villages large amounts of maize forage and rice straw become available in the wet season, but because of their low quality, this does not help to improve the quality of the ration. The performance of animals in the wet season may also be affected by soil contamination of feeds leading to selective consumption and lower intake. So, various factors including quantity and quality of available forages, rainfall and selection of feed by the animal in different periods of the year, can individually or in conjunction, form a constraint for production.

There are considerable differences between forages in terms of the amount of dry matter collected per hour. In both villages collection of maize straw takes the least time (see Table 6.9), while, especially in Putukrejo, collection of tree leaves is very time-consuming. Farmers mention ease of collection as one of the factors determining their choice of feed. Nevertheless, during all seasons the proportion of gliricidia was higher in the ration fed than in the forage produced, both in Kedungsalam and Putukrejo. Similarly, during the wet season, the proportion of maize forage in Kedungsalam was much lower in the ration fed than in the forage produced. Thus, although the time factor is important, it is certainly not the only factor determining the choice of feeds. Farmers are also well aware of the importance of feed quality. In general there is a shift to higher quality of the ration fed as compared to the forage produced. However, cassava leaves, which are high in both digestibility and crude protein, are used in limited amounts to avoid HCN poisoning. In addition, farmers store considerable amounts of feed for use in leaner seasons. The results of model calculations (Chapter 7) suggest that in both villages herd size and feeding management systems are well adapted to obtain maximum physical production from the available feed resources. At first sight, the response lines for the physical production (D and especially E) in Figures 7.2 and 7.3 suggest that farmers could obtain higher total benefits (from increased intangible benefits) if herd sizes were further increased. However, the model does not distinguish between different classes of animals. As a result, the effect of extremely low feeding levels on herd fertility is not incorporated. In addition, the results of the model studies are based on the feed table in a year with normal rainfall. Even with the present herd size, farmers had to import rice straw in periods of drought and many had to pay for that by selling their animals and retaining them on the farm in sharing. If herd size were to increase further, the problems in periods of drought would also increase. The analysis strongly suggests that biological production can only be increased by increasing the amount of high quality feeds.

The adagio in policy statements on ruminant feeding strategies for tropical livestock systems seems to be 'how to make better use of local low quality feed resources'. For several decades a large volume of research has been dedicated to supplementation and/or chemical treatment of such low quality feeds. The principles of these technologies have been well established several decades ago, but adoption by farmers has been below expectation. The reason for this is that, although technical responses were encouraging, these technologies were mostly not economically feasible (Zemmelink, 1995). Traditional feeding trials provide useful information, but describe only a small part of the total production system. In such trials, low quality feeds and supplements are isolated from other feed resources and the actual production systems. They focus on the question how animals can be made to produce on low quality feeds. The question that should be asked is: how, when and to what extent can low quality feeds be used to optimize the utilization of the total package of available feeds (van Bruchem and Zemmelink, 1995). Our analysis shows that farmers in Putukrejo and Kedungsalam use their feed resources quite strategically. Biological production can only be increased by increasing the amount of high quality feeds. Only when other benefits such as financing and insurance, and also manure (e.g. when it is used for fuel as in India and parts of Africa) have a very high value, can a higher proportion of the poorer feeds be included in the ration. This will, however, lead to a lower production of meat and/or milk. The starting point in ruminant feeding strategies should be an analysis of the total feed resource base and the objectives of the production system.

8.3. Options and constraints for improvements

In marginal areas, livestock and agriculture in general, are usually described in terms of low production and productivity. This applies to Africa (van Klink, 1994; von Kaufmann and Fitzhugh, 1993) as well as Asia (Devendra, 1993[b]). Devendra (1993[b]) claims that ruminants are inadequately exploited and managed. The pressing need to feed the growing populations and the fact that there is little scope for the expansion of the existing agricultural area has forced development agencies to develop a policy of intensifying farming on the existing agricultural areas (Winrock, 1992). In resource-poor areas, socio-economic and technical constraints form a greater hindrance for increasing production than in the so called 'Green revolution' areas (Chambers *et al.*, 1989). Chapter 1 indicates that the introduction of new technologies in the present study area has also proved difficult. Fujisaka (1994) has described failures of development agencies in improving production of upland mixed-farming systems in South-East Asia. Anderson (1992) developed hypotheses why production increases are so difficult for the resource-poor farmer. Although his article deals mainly with the African situation, the similarities with the present study area are striking. Anderson mentions that low uptake of 'improved' technologies is related to the fact that within the limited resources and opportunities open to farmers, the new technologies are not more profitable than existing practices. In addition to this, the technology is often too risky, and is impossible to implement in time because of labour shortage and the lack of supporting infrastructure.

Ellis (1988) distinguishes two approaches with regard to technical change in agriculture: the improvement approach and the transformation approach. The improvement approach means that if farmers are technically inefficient, farmer education and extension have a major role. The transformation approach implies that if peasants are efficient within the constraints of existing technology, only dramatic changes in technology will do. Chambers *et al.* (1989) compiled many examples from efforts to introduce new technologies to the 'diverse risk prone areas' in the tropics. The present study area also falls into this category. Chambers *et al.* (1989) showed that farmers in such areas are continuously experimenting, adapting and innovating, to survive. They classify, choose, improvise and adapt technologies depending on their circumstances. On this basis, Chambers *et al.* (1989) concluded that what the farmers need is not so much a standard package of technology or practices but more a basket of choices. Petheram (1992) and Fujisaka (1994) also indicate that before they adopt an innovation farmers need to see that it works better than their present practices. Differences in management practices of individual farmers do exist and they can act as catalysts for changes in the system (van der Ploeg and Roep, 1990; Roep *et al.*, 1991; van Klink, 1994; de Jong, 1996). Nitis (personal communication) also uses progressive farmers to introduce new forage growing practices in Bali. Preston and Leng (1987) claim that in most developing countries livestock play a fundamental and often catalytic role in the development process. However, in the marginal upland areas in Java, changes in the use of ruminants have always followed the changes in overall development of the area (Palte, 1989; Nibbering, 1991). It is expected that in the future, changes in livestock keeping will continue to depend on changes in the crop production and in the non-agricultural sector.

In the present study area, accumulation of live weight in the herd is the most important aim of rearing ruminants. Efforts to improve liveweight production must be directed both to the cows and the calves. Technically, this may be done through control of *Toxocara* using anthelmintics to treat young calves and the improvement of the feed resource base, especially the quality of feeds for pregnant and lactating cows. The use of anthelmintics involves cash inputs and the resulting weight gain is unpredictable. So, its acceptance by farmers is uncertain. However, preliminary trials in Thailand have been encouraging, although confronted with difficulties (Juengling *et al.*, 1993).

As shown by Figures 7.5 and 7.6, increasing the amount of gliricidia is a promising way of improving production. Both Putukrejo and Kedungsalam have open areas of *bongkoran* (now covered with native grasses) with the potential to produce more gliricidia. Gliricidia has a higher feeding value and also its production is less seasonal. Planting more gliricidia may, however, lead to questions such as who will plant the trees and who will reap the benefits. Those interested in the innovation may be restrained from investing in it, as others may take the advantage based on the tradition of sharing forage resources. Any innovation in forage improvement must be formulated as a community endeavour and cooperative efforts are needed to solve the problem. This should involve farmers, the forestry department, the owners of the land and the big cattle owners. It must be made clear who will pay the costs, how the products are to be distributed and what benefits might be obtained by the different parties involved. However, conflicting interests between parties may arise. The forestry department might argue that other plants, such as teak and albizia, can give a higher return to the land than gliricidia The wealthy farmers may find that growing firewood gives greater benefits. These constraints to forage development are characteristic not only of Kedungsalam and Putukrejo but also of other upland areas in Java. Perkins *et al.* (1985), for example, discussed these problems as part of the constraints for forage development in many village communities in South-East Asia.

A technology such as the Three Strata Farming System (TSFS, Nitis *et al.*, 1989) is a good option to enable farmers to become self-sufficient in forage production. One unit TSFS includes 0.25 ha of land, consisting of 0.16 ha core area, 0.09 ha peripheral area and 200 m circumference. The system is ready to be used two years after establishment and can maintain 4 cattle per ha. It has been found that compared with non-TSFS, farmers with TSFS spend less time in feeding their cattle and are able to produce 1.5 t firewood y^{-1}. TSFS decreased soil erosion in the core area by 4.5 mm y^{-1}. The cattle gained 19% more live weight and reached market weight 13% faster (Devendra, 1993[a]). However, TSFS has its drawbacks. It is only suitable for farmers who have at least 0.25 ha of land and are able to sacrifice 0.09 ha of the land for grass and legumes. Also, if it is to work, it must be accompanied by private use of the primary outputs. In other words, restricted access to forages with emphasis on individual ownership of resources must also be developed in the community.

In this study, the overall liveweight gain of cattle was found to be 0.154 kg d^{-1}. The farmers considered the technically sound option of enhancing the cattle's liveweight gain in the present production system by using concentrate feeds to be too costly. In the middle and upper slopes of volcanic areas in East Java, the introduction of dairy cattle has led to a major change in the farming system. In the limestone area of South Malang, however, the availability of feeds and in particular the quality of these feeds is less favourable, hence the low production levels found in this study and this, combined with low fertility rates, implies that dairy production will only be possible in this area with large inputs of concentrates (Ibrahim *et al.*, 1992) and by selecting specific forages. The latter would require a high input of labour. Also, if the best forages were used selectively for dairy cattle, the mean quality of the remaining materials would decrease, making it more difficult to feed other animals. Another problem in the limestone area is the provision of drinking water, especially in periods of drought. Dairying would, therefore, appear to be an unattractive option for farmers in the limestone area. New feeding and production strategies, including bull fattening and dairy cattle should be carefully screened and tested, e.g. by biological and economic modelling techniques and on-farm testing, before they are recommended to the farmer.

The limestone areas experience may also be relevant for other livestock production systems in South-East Asia. The conclusion that changes in livestock will continue to depend on changes in the crop production also apply to other resource-poor mixed farming systems. This implies that feed quality remains the major constraint to increasing biological production. Marked changes in the meso- and macroeconomic pressures (transformation approach) to which livestock is subjected are needed to intensify production systems on the basis of external inputs.

The inability of farmers to adopt and finance the cost of new technologies is a common problem in many parts in South-East and South Asia, for crop production and soil conservation as well as ruminant production (Fujisaka, 1994; Jackson, 1983; Devendra, 1993[a]). Proposed new technologies are often based on the idea that efficient production requires that animals should be fed to meet certain (often high) production targets. However, the concept of feeding according to standards loses much of its value in low-input systems (Schiere and de Wit, 1993; Schiere, 1995). Feeding according to standards assumes a demand-driven production system, but such systems are only feasible in appropriate physical and economic environments (consumers with large purchasing power, e.g.), that allow farmers to use high quality inputs (including high quality forages or concentrates or both). The animal production of resource-poor farmers operating in a less favourable environment can be characterized as supply-driven (Bayer and Zemmelink, 1996). Such farmers utilize available resources as best as they can, i.e. they act as utility maximizers rather than production maximizers. Their poor economic resources force them to avoid the economic risks of new technologies as much as possible. Farmers who rear shared animals may be even more reluctant to pay for the costs of a new technology if half of the outputs go to the owner of the animals.

8.4. The methodology evaluated

Collection and analysis of data

The objectives mentioned in Chapter 1 had to be transformed into research questions. The data to answer the questions were gathered by interviewing farmers and key informants, field observations and measurements, laboratory analyses and studying primary and secondary data from the literature.

It should be recalled that the study was part of the INRES project in which the Farming Systems Analysis approach (Shaner *et al.*, 1982; Fresco *et al.*, 1990) was used. The studies started with a Reconnaissance Survey and based on its results, farm households which were considered to be representative for the 'reccommendation domain', were selected following the criteria mentioned in Chapter 1. These criteria were partly based on the needs of other disciplines participating in the project. As explained in Section 6.4.5 this may have caused the sample to be less than fully representative for the study on livestock feeding practices. It was also found that reliable information concerning farm households' possessions could not be obtained in the quick survey. Farmers are reluctant to give this information to outsiders. It was only after a more intensive survey, in which the investigators stayed in the village, that it was found that some respondents in Putukrejo did possess sugarcane fields and that their farms were larger than originally stated. Correct information on land holdings became available only very gradually during a subsequent intensive farm household survey, and often as a result of casual remarks made by the farmer or other members of the household while discussing other subjects. Farmers also tended to overestimate or underestimate the size of their land parcels. Accurate information could only be obtained by detailed observation or measurement. Land and animals may be owned, rented or shared and the area of land farmed may vary because farmers gain access to new plots or animals, or abandon plots or dispose of animals they have been keeping. Thus, obtaining accurate information on the physical resource base of respondent farms was a complicated and time-consuming process. To obtain the full picture, the information collected by the technical disciplines had to be combined with information collected by the socio-economic disciplines, e.g. on tenureship arrangements.

The success of simulation models depends primarily on the reliability of the inputs. Chapter 6 describes the great efforts which were needed to collect quantitative and qualitative data on the availability and utilization of feeds. The large variation between and within seasons, as well as the variation between years, makes data collection extremely labour intensive. Next, the large differences between individual feeds and their seasonal supply make it difficult to evaluate farmers' practices in more than qualitative terms. The INRES project aimed to produce a quantitative evaluation through model studies. Any model, however, is no more than a strongly simplified description of reality. The model used in this study (Chapter 7) did not include many of the factors known to affect the production of livestock, such as health status, genetic characteristics of the animals, different classes of animals and the entire complex of socio-economic factors. Furthermore, small changes in parameter values used in the model can have a large combined effect on the results of calculations. In spite of these drawbacks and shortcomings the model was useful in shedding light on farmers' practices in general and in providing quantitative results. It also helped to identify possible technical options for improving existing practises.

Perhaps the major shortcoming of the present study is that insufficient field data were collected on reproduction. To estimate reproductive parameters a large number of animals should be monitored for at least one year (but preferably two). Another shortcoming was that the model does not calculate the effect of low feeding levels on reproduction. It is, therefore, suggested that in future studies on small-scale livestock farming, information is collected on factors related to breeding management which could affect performance and thus the economies of the system, such as inbreeding, heat detection and calving intervals. Like the forage system, the existing breeding system was observed to transcend farm household or village boundaries. If a farmer needs a bull to breed his cow, he often has to borrow it from another farm, under the condition of providing the day's feed for the bull. This underlines the fact that in contrast to studies on crop production, any study on ruminant production aspects of a farm-household system cannot be bound by the farm household boundary.

Interdisciplinary research

The great advantage of an interdisciplinary research team lies in the interaction between various disciplines, which helps understanding to be reached about the complexity of the farming and household system. This allows the farm household to be viewed holistically. In this study, for example, it was found that not only the fodder actually given to the ruminants but also the farmers' access to cattle depends upon land use, customary rights, availability of labour and the ease of collection of forage. Working with colleagues from other disciplines also makes an investigator aware of the consequences of technically sound advice, e.g. to supplement the livestock ration with concentrates or gliricidia leaves. However, it also has disadvantages, the main one being the long time it takes for a constraint from another discipline to be properly identified and described in quantitative terms so that it can be incorporated in one's own studies. The initial stage in establishing the team is crucial mainly because different interpretations of phenomena by persons with different backgrounds and experience must be unified.

An interdisciplinary team also leads to the situation of each of the disciplines having to compromise on criteria for selecting the sample on which disciplinary parameter values are based. In this study, for instance, it was accepted that the criteria for selecting farm households included the possession of a home garden to meet the requirements for studies on multistorey cropping by the agronomist. As a result, the data on the composition of rations may be slightly biased (see Section 6.4.5). The limited budget and manpower available prevented the number of farms studied to be increased to fully meet the needs of all disciplines involved. These disadvantages of interdisciplinary work are, however, outweighed by the advantage of getting a much better insight into the farm household system as a whole.

As a result, not only the animal production discipline, but also other disciplines, in the INRES project became aware of the versatility of cattle in supporting the well-being of farm households. The interdisciplinary approach emphasized that cattle in low external input systems are not kept just for biological production as is commonly discussed in the animal production literature and taught at our agricultural or animal science colleges and university faculties. Also, in regional development programmes an interdisciplinary approach is necessary to understand the farming systems and the possible implications of interventions.

SUMMARY 9

Maintaining and improving the productivity of resources in upland areas has been a priority in Indonesia since the 1980's when the country became self-sufficient in rice production. The agro-ecological characteristics of the upland areas are far more complex and diverse than those of the lowland paddy area. Upland agriculture is associated with resource-poor farmers, land degradation, and low crop and animal production. The search for suitable methods for maintaining and improving the productivity of resources in upland areas is still in its infancy. The area chosen to carry out this study on the relevance of ruminants for upland mixed farming systems was the limestone area, a marginal upland area, in the southern part of Malang regency in East Java.

It is generally claimed that ruminants are the best way to accumulate capital and are important for the maintenance of crop production. However, the various roles of ruminants have usually only been described qualitatively. Cattle are by far the most important livestock in the limestone area. The common premise is that cattle production and productivity in upland areas is low and that it is mainly a shortage of feed that limits production. This research was conducted with the following objectives:

1. to identify and quantify the roles of ruminants in the farm-household systems
2. to quantify the resource base and its utilization
3. to relate the various roles of ruminants in the farming systems to the feed resource base with a view of understanding the overall system and identifying possible improvements.

The data collection was done within the framework of the INterdisciplinary agricultural RESearch training (INRES) project; an on-the-job research training project in Farming Systems Analysis (FSA) executed by staff from Brawijaya University, Malang, Indonesia, and Wageningen Agricultural University and Leiden University, The Netherlands. INRES aimed to develop scenarios for the development of farming systems in the limestone area. Two villages were selected as research sites because of their differences in land use and soil characteristics, i.e. one village where land use is dominated by sugarcane and annual crops on relatively flat areas with deep soils and one village where agroforestry is becoming increasingly important in areas with steep slopes and shallow, stony soils.

Based on their day to day interactions with the economic environment, farmers integrate ruminants in their mixed farming systems in balance with their objectives and resources. They aim at both physical production (progeny, increase in body weight, manure, draught power) and intangible benefits. The intangible benefits comprise the

capital embodied in animals kept and the possibility of disposing of animals as and when required: insurance and finance. In the two villages studied, the value of intangible products from cattle keeping is close to one-third of the total added value from the physical products. If the intangible benefits are counted in, farmers arrive at a daily return to labour similar to the ongoing daily wages in the agricultural sector.

Farmers emphasize the importance of live weight accumulated in the herd, because this also increases the benefits from intangible products. Manure production is limited by herd size, but manure is used optimally by putting it in the planting holes. Systems for sharing ruminants that have developed in the community enable the available labour and capital to be better used and distribute wealth more evenly in the village. The institution of sharing also plays a major role in replenishing herds after periods of severe drought. The relatively low importance of cattle for land cultivation is related to the land use system. In the sugarcane oriented system, cattle were mainly used to cultivate the better quality land, whereas in the agroforestry system cattle were hardly used for land cultivation. Overall, by keeping ruminants, farmers efficiently allocate their resources i.e. labour and capital according to their household objectives. The objectives in research and development programmes should be set in relation to all benefits of livestock keeping.

Farmers are confronted with a large variety of feeds and a great seasonal and annual variation in feed supply. The differences in land use between the two villages have important consequences for the feed resource base. In the sugarcane-oriented system a relatively large part of the feed consists of crop residues, mostly originating from the sugarcane. In the agroforestry-oriented system more tree leaves, especially gliricidia are included. Livestock keepers obtain a large proportion of feeds off-farm, both from communal areas and from crop fields operated by other farms. Hence, the boundaries of the livestock production sub-system are not the same as those for farm land (crop production). The exchange of feeds between farms is related to the exchange of labour in harvest operations and is an important mechanism to avoid wastage of feeds. Farmers mention ease of collection as one of the factors influencing their choice of feeds, but are also well aware of differences in quality. They tend to use the better quality feeds to feed their animals. In both villages the feeding system and herd size are well adapted to the available resources. Biological production can only be increased by increasing the amounts of high quality feeds.

This study has demonstrated that farmers in the marginal uplands are efficient within the constraints of the existing farming systems. Small changes in management including control of helminths, providing better feed for pregnant and lactating cows and planting more gliricidia will be beneficial for the improvement of ruminant production. However, farmers' adoption of these measures may be constrained by socio-economic factors such as the inability to reallocate labour and cash resources, and the ownership of resources and products. Complex innovations and dramatic changes, e.g. introduction of dairy cattle or cattle fattening schemes, would be difficult because of the limited physical and economic resource base. High risk innovations need to be tested through public funds before they are recommended to the small farmers. Farmers should be well informed about alternative management practices. Introduction of improved management practices should, however, exploit the fact that farmers themselves classify, choose, improvise and adapt technologies depending on their circumstances.

Simulation models are a useful tool for understanding present feeding practices and evaluation of proposed new technologies. However, their results depend on reliable input data. Reliable field data on livestock cannot be collected in a quick survey. Developing a close relationship with the farmers is well worth the time and effort involved, as this allows more reliable data to be collected. Spending time and labour on collecting detailed data pays dividends in improving the accuracy and reliability of the data and ultimately benefits the validity of the study. Interdisciplinary work requires compromises with regard to e.g. sampling criteria, but gives a much better insight into complex farming household systems and the versatility of livestock in supporting human welfare. An interdisciplinary team is essential if development of a region is the aim.

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Appendix 1a Amounts of feed available in Putukrejo (t DM $month^{-1}$).

Feed[1]	Ca	Gl	SCR	SCL	SCT	NG	ML	EG	RS	Total
<u>Dry season 1990</u>										
May	5	4	-	-	23	55	-	2	-	89
June	9	4	-	-	407	38	63	2	-	523
July	42	4	-	-	375	35	-	2	-	458
August	28	4	-	-	459	25	14	2	-	532
September	7	4	5	-	435	24	-	2	-	477
October	1	4	82	-	236	26	-	2	-	351
<u>Wet season 1990/1991</u>										
November		8	75	-	48	41	-	2	-	174
December	1	8	92	-	35	48	-	3	214	401
January	-	8	88	5	-	46	197	3	214	561
February	-	8	47	96	-	21	183	3	-	358
March	-	8	10	89	-	30	105	3	303	548
April	5	8	7	109	-	31	-	3	332	495
<u>Dry season 1991</u>										
May	5	4	-	103	-	11	-	2	89	214
June	9	4	-	56	62	0	-	2	-	133
July	42	4	-	11	314	0	63	2	-	436
August	28	4	-	8	242	-	14	2	-	298
September	7	4	-	-	209	-	-	2	-	222
October	1	4	-	-	133	-	-	2	-	140
Dry season 1990	92	24	87	-	1935	203	77	12	1063	2430
Wet season 1990/1991	6	48	319	299	83	217	485	17	89	2537
Dry season 1991	92	24	-	178	960	11	77	12	-	1443

[1]Ca: Cassava leaves; Gl: Gliricidia; SCR: Sugarcane ratoon; SCL: Sugarcane leaves; SCT: Sugarcane tops; NG: Native grass; ML: Maize forage; EG: Elephant grass; RS: Rice straw

Appendix 1b Amounts of feed available in Kedungsalam (t DM $month^{-1}$).

Feed[1]	Ca	Gl	SCR	SCL	SCT	NG	ML	EG	RS	Total
Dry season 1990										
May	31	44	-	-	-	213	-	4	202	494
June	54	44	-	-	-	189	-	4	-	291
July	237	44	-	-	-	186	357	4	-	828
August	161	44	-	-	-	174	79	4	-	462
September	38	44	-	-	-	174	-	4	-	260
October	8	44	-	-	-	175	-	4	-	231
Wet season 1990/1991										
November	-	95	-	-	-	195	-	4	-	294
December	8	95	-	-	-	204	-	8	88	403
January	-	95	-	-	-	202	1110	8	88	1503
February	-	95	-	-	-	168	1031	8	-	1302
March	-	95	-	-	-	180	595	8	290	1168
April	31	95	-	-	-	180	-	8	357	671
Dry season 1991										
May	31	44	-	-	-	156	-	4	202	437
June	54	44	-	-	-	141	-	4	-	243
July	237	44	-	-	-	141	357	4	-	783
August	161	44	-	-	-	140	79	4	-	428
September	38	44	-	-	-	140	-	4	-	226
October	8	44	-	-	-	140	-	4	-	196
Dry season 1990	529	264	-	-	-	1111	436	24	202	2566
Wet season 1990/1991	39	570	-	-	-	1129	2736	44	823	5341
Dry season 1991	529	264	-	-	-	858	436	24	202	2313

[1]Ca: Cassava leaves; Gl: Gliricidia; SCR: Sugarcane ratoon; SCL: Sugarcane leaves; SCT: Sugarcane tops; NG: Native grass; ML: Maize forage; EG: Elephant grass; RS: Rice straw

SAMENVATTING

In Indonesië heeft het in stand houden en verbeteren van de produktiviteit van hulpbronnen in hoger gelegen gebieden prioriteit sinds de tachtiger jaren, vanaf het moment dat het land zelfvoorzienend werd in rijstproduktie. De landbouwkundige c.q. ecologische kenmerken van deze gebieden zijn veel complexer en diverser dan die van de rijstgebieden in het laagland. Landbouw in de hoger gelegen gebieden kenmerkt zich door beperkte hulpbronnen, land degradatie en lage gewas- en dierlijke produktie. Het zoeken naar geschikte methodes voor het handhaven en verbeteren van de produktiviteit in deze gebieden staat nog steeds in de kinderschoenen. Het gebied dat uitgekozen werd om de relevantie van herkauwers voor de gemengde landbouwsystemen te bestuderen, was het kalksteengebied, een marginaal gebied in het zuidelijke gedeelte van het regentschap Malang in Oost Java.

Het wordt algemeen aangenomen dat herkauwers de beste manier zijn om kapitaal te accumuleren en dat zij belangrijk zijn voor de gewasproduktie. De verschillende functies van herkauwers worden in het algemeen slechts kwalitatief beschreven. Rundvee is het meest belangrijke landbouwhuisdier in het kalksteengebied. De algemene veronderstelling is dat produktie en produktiviteit van rundvee in de hoger gelegen gebieden laag is en dat het voornamelijk het tekort aan voer is dat de produktie beperkt.

Dit onderzoek werd uitgevoerd met de volgende doelstellingen:

1. het identificeren en kwantificeren van de functies van herkauwers in de bedrijfssystemen
2. het kwantificeren van de beschikbaarheid van hulpbronnen en het gebruik hiervan
3. het relateren van de verschillende functies die herkauwers hebben in de bedrijfssystemen aan de voervoorziening ten einde het gehele systeem te begrijpen en mogelijke verbeteringen voor te stellen.

Het verzamelen van gegevens werd gedaan in het kader van het "INterdisciplinary agricultural RESearch training (INRES)" project; een onderzoek c.q. opleidingsproject in Landbouw Systeem Analyse, uitgevoerd door staf van de Brawijaya Universiteit te Malang, Indonesië, de Landbouwuniversiteit Wageningen en de Universiteit van Leiden, Nederland. De doelstelling van INRES was om ontwikkelingsscenario's te maken voor landbouwsystemen in het kalksteengebied. Twee dorpen werden geselecteerd als onderzoekgebied, gebaseerd op hun verschillen in landgebruik en bodemkenmerken. Een dorp waar het landgebruik wordt overheerst door suikerriet en éénjarige gewassen op relatief vlakke stukken grond met diepe teeltaarde en een dorp waar gemengde landbouw/bosbouw systemen in toenemende mate belangrijk worden in een gebied met steile hellingen en ondiepe, steenhoudende gronden.

Gebaseerd op de dagelijkse interactie met de economische omgeving, integreren de boeren herkauwers in hun gemengde landbouwsystemen. Zij richten zich op zowel fysieke produktie (nakomelingen, toename in lichaamsgewicht, mest, trekkracht) als niet-fysieke aspecten. Deze laatsten omvatten kapitaal, belichaamd in gehouden dieren en de mogelijkheid om dieren af te zetten wanneer dit gewenst is: verzekering en financiering. De waarde hiervan in de twee dorpen betrokken bij het onderzoek was bijna éénderde van de totale toegevoegde waarde van de fysieke produkten. Als de niet-fysieke opbrengsten meegerekend worden, dan komen de boeren tot daglonen voor hun arbeid die gebruikelijk zijn in de landbouwsector. De doelstellingen van onderzoeks- en ontwikkelingsprogramma's moeten zodanig geformuleerd worden dat met alle redenen voor het houden van vee rekening wordt gehouden.

Boeren benadrukken het belang van de gewichtsaccumulatie (nakomelingen, toename in lichaamsgewicht) in de veestapel, omdat dit ook de niet-fysieke baten vermeerdert. Mestproduktie is beperkt vanwege de omvang van de veestapel, echter mest wordt optimaal gebruikt door het in de plantgaten te brengen. Systemen voor het uitbesteden van vee, welke in de gemeenschap ontwikkeld zijn, maken het mogelijk beschikbare arbeid en kapitaal beter te benutten en verdelen de rijkdom meer gelijkmatig over het dorp. Het uitbesteden van vee speelt ook een belangrijke rol bij het weer op peil brengen van de veestapel na periodes van ernstige droogte. Het geringe belang van vee voor het bewerken van land staat in verband met het landgebruik. In het op suikerriet gebaseerde systeem wordt vee voornamelijk gebruikt voor het bewerken van de betere gronden, terwijl in het landbouw/bosbouw systeem vee nauwelijks gebruikt wordt voor grondbewerking. Er kan gesteld worden dat boeren, door vee te houden, zeer efficiënt hun hulpbronnen, arbeid en kapitaal, bestemmen overeenkomstig de doelstellingen van hun huishouding. Bij het formuleren van onderzoeks- en ontwikkelingsprogramma's dient rekening te worden gehouden met de verschillende funkties van vee.

Boeren worden geconfronteerd met een grote verscheidenheid aan voeders en een grote seizoens- en jaar variatie in voeropbrengsten. De verschillen in landgebruik tussen de twee dorpen hebben belangrijke gevolgen voor de voervoorziening. In het op suikerriet gebaseerde systeem bestaat een relatief groot deel van het voer uit gewasresten, voornamelijk afkomstig van suikerriet. In het op landbouw/bosbouw georiënteerde systeem worden meer boombladeren, voornamelijk gliricidia, benut. Veehouders halen een groot deel van hun voer van buiten het bedrijf, zowel van gemeenschapsgronden als van gewassen geteeld op andere bedrijven. Dientengevolge zijn de grenzen van het veeteelt sub-systeem niet dezelfde als die voor het bedrijf (gewasproduktie). De uitwisseling van voeders tussen huishoudens is gerelateerd aan de uitwisseling van arbeid tijdens oogstwerkzaamheden en is een belangrijk mechanisme om verspilling van voer te voorkomen. Boeren vermelden dat de tijd benodigd voor het verzamelen van voeders één van de factoren is welke hun voerkeuze beïnvloedt. Ze zijn zich echter ook bewust van de verschillen in kwaliteit. Ze streven ernaar om de kwalitatief betere voeders aan hun dieren te geven. In beide dorpen was het voersysteem goed aangepast aan de beschikbare voeders. Biologische produktie kan alleen worden verhoogd door de hoeveelheden hoogwaardig voer te vergroten.

Deze studie heeft aangetoond dat boeren in de marginale, hoger gelegen gebieden efficiënt werken binnen de beperkingen van de bestaande bedrijfssystemen. Kleine veranderingen in het management, daarbij inbegrepen bestrijding van wormen (*Toxocara*), verstrekking van beter voer voor drachtige en melkgevende runderen en planten van gliricidia, kunnen bijdragen aan de verbetering van de produktie van runderen. De toepassing van al deze maatregelen door de boeren wordt echter bemoeilijkt door sociaal-economische factoren, zoals de onmogelijkheid tot herverdeling van arbeid en financiële middelen, en de eigendomsrechten van hulpbronnen en produkten. Het invoeren van complexe vernieuwingen en drastische veranderingen, b.v. introductie van melkvee of mesterij schema's, kan moeilijk uitvoerbaar zijn vanwege de beperkte fysische en economische hulpbronnen. Hoog risico dragende vernieuwingen dienen eerst te worden onderzocht via publieke fondsen voordat ze aan de boeren worden aanbevolen. Boeren dienen goed geïnformeerd te worden over alternatieve bedrijfsvoering. Invoering van veranderingen in bedrijfsvoering moet echter uitbuiten dat boeren zelf klassificeren, kiezen, improviseren en technologieën aanpassen, afhankelijk van hun omstandigheden.

Simulatiemodellen zijn een bruikbaar hulpmiddel om de huidige voerpraktijken te begrijpen en nieuwe voorgestelde technologieën te evalueren. De resultaten zijn echter afhankelijk van de invoer van betrouwbare data. Betrouwbare data ten aanzien van de veehouderij kunnen niet worden verzameld in een vluchtig veldonderzoek. Het ontwikkelen van een goede verstandhouding met de boeren is zeker de tijd en moeite waard. De tijd en arbeid besteed aan het verzamelen van gedetailleerde data komen tot uiting in de accuratesse en betrouwbaarheid van de data en komen uiteindelijk de validiteit van de studie ten goede. Interdisciplinair werk vraagt compromissen met betrekking tot b.v. de criteria voor gegevensverzameling, maar geeft een veel beter inzicht in de complexe bedrijfssystemen en veelzijdigheid van de veehouderij ter ondersteuning van het menselijk welzijn. Een interdisciplinair team is essentieel indien streekontwikkeling het doel is.

RINGKASAN

Pemeliharaan dan peningkatan produktivitas sumberdaya kawasan lahan kering menjadi prioritas sejak Indonesia berhasil dalam swasembada beras pada tahun 1980-an. Karakteristik agro-ekologi di kawasan lahan kering lebih komplek dan beragam dibandingkan di kawasan persawahan. Pertanian lahan kering memiliki asosiasi dengan petani miskin sumberdaya, degradasi lahan serta produksi pertanian tanaman dan ternak yang rendah. Rekayasa metoda yang tepat untuk perbaikan dan peningkatan produktivitas sumberdaya kawasan lahan kering dapat dikatakan masih baru. Untuk penelitian ini, kawasan yang dipilih untuk mempelajari relevansi ternak ruminansia dalam sistem pertanian campuran adalah kawasan pertanian lahan kering marjinal di daerah pegunungan kapur di selatan Kabupaten Malang di Jawa Timur.

Pada umumnya ternak ruminansia dianggap memiliki peran sebagai sarana akumulasi modal dan penting untuk kegiatan produksi tanaman. Namun, peran-peran itu umumnya dinyatakan secara kualitatif. Di daerah pegunungan kapur, ternak sapi memiliki peran yang penting namun seringkali produksi dan produktivitas-nya dinyatakan rendah sebagai akibat tidak tercukupinya kebutuhan pakan. Dalam penelitian ini tujuan-tujuan yang ingin dicapai meliputi:

1. Identifikasi dan kuantifikasi peran ternak ruminansia dalam sistem rumahtangga tani
2. Kuantifikasi sumberdaya yang tersedia serta penggunaannya
3. Menghubungkan berbagai peran ruminansia dalam sistem pertanian dengan sumberdaya yang tersedia untuk mendapatkan kejelasan sistem produksi yang berlangsung dan identifikasi kemungkinan perbaikannya.

Pengumpulan data dilakukan dalam kerangka kinerja proyek pelatihan penelitian lintas disiplin (proyek INRES); yaitu proyek pelatihan Analisis Sistem Pertanian yang dilakukan oleh staf Universitas Brawijaya, Malang, Indonesia, Universitas Pertanian Wageningen dan Universitas Leiden Belanda. Proyek tersebut bertujuan mengembangkan skenario-skenario untuk pengembangan sistem pertanian di kawasan penelitian. Dua desa dipilih sebagai lokasi penelitian berdasarkan perbedaan tata guna lahan serta karakteristik lahannya. Satu desa berada berada di kawasan yang relatif datar, solum tanahnya dalam, tataguna lahannya didominasi tanaman tebu serta tanaman semusim sedangkan satu desa lainnya berbukit dengan kemiringan yang tajam, solum tanahnya dangkal, tanah berkerikil sampai berbatu dimana sistem agro-forestry semakin berkembang.

Selaras dengan interaksinya dengan lingkungan ekonomi yang berlangsung dari hari ke hari, petani di lokasi penelitian meng-integrasi-kan ruminansia dalam sistem pertanian campuran yang dikelolanya secara seimbang dengan tujuan mereka serta

sumberdaya yang dimilikinya. Petani memelihara ruminansia untuk mendapatkan produksi fisik (anak, peningkatan bobot badan, pupuk organik dan tenaga kerja) serta keuntungan non-fisik. Keuntungan non-fisik meliputi aspek asuransi dan biaya berupa kapital dalam bentuk ternak yang dapat dijual setiap saat diperlukan. Pada kedua desa yang diteliti, nilai keuntungan non-fisik dari pemeliharaan sapi mencapai sekitar sepertiga dari total nilai tambah yang diperoleh dari produksi fisik. Dengan memperhitungkan keuntungan non-fisik, pemeliharaan sapi memberikan pendapatan harian untuk tenaga kerja yang besarnya sama dengan upah harian bekerja di sektor pertanian tanaman.

Petani memberikan tekanan pada pentingnya akumulasi bobot badan dari populasi ternak yang dipelihara karena hal itu juga meningkatkan keuntungan-keuntungan non-fisik. Jumlah populasi ternak yang dipelihara per unit rumahtangga tani merupakan faktor pembatas untuk produksi pupuk organik, namun secara optimal pupuk organik yang dihasilkan dimanfaatkan dengan cara memasukkan pupuk organik yang tersedia ke dalam lubang tanam. Sistim gaduhan yang berkembang dalam komunitas pertanian memungkinkan pemanfaatan tenaga kerja yang tersedia dan kapital secara lebih baik dan kesejahteraan dapat terdistribusi lebih merata pada desa-desa yang diteliti. Lembaga sistim gaduhan juga berperan untuk mempertahankan populasi ruminansia setelah periode musim kemarau panjang. Pemanfaatan sapi untuk pengolahan lahan relatif rendah dan hal itu berkaitan dengan sistim penggunaan lahan. Pada sistem yang berorientasi produksi tanaman tebu, sapi digunakan untuk mengolah lahan berkualitas baik sedangan dalam sistem agro-forestry maka pemanfaatan sapi untuk pengolahan lahan boleh dikatakan sangat rendah. Secara keseluruhan, dapat dikatakan bahwa dengan memelihara ruminansia maka petani dapat secara lebih efisien menggunakan tenaga kerja dan sumberdaya yang tersedia sesuai dengan tujuan rumahtangga-nya.

Setiap saat petani dihadapkan pada keragaman pakan yang besar serta keragaman pasokan pakan musiman maupun tahunan. Perbedaan tataguna lahan antara dua desa yang diteliti memberikan konsekuensi terhadap sumberdaya pakan. Pada kawasan yang didominasi oleh tanaman tebu, relatif sebagian besar pakan tersedia dalam bentuk limbah pertanian khususnya yang berasal dari tanaman tebu. Sedangkan pada kawasan yang di dominasi oleh sistim agro-forestry maka lebih banyak daun tanaman tahunan digunakan sebagai pakan, khususnya gliricidia. Sebagian besar pakan untuk ternak diperoleh petani dari luar batas lahan yang dikuasainya, termasuk kawasan umum atau lahan pertanian yang dioperasikan oleh petani lain. Dengan demikian, batas sistem produksi ternak ruminansia tidak sama dengan batas sistem produksi tanaman pertanian. Pertukaran bahan pakan yang terjadi antar unit usahatani memiliki kaitan dengan pertukaran tenaga kerja dalam proses panen dan merupakan mekanisme penting untuk mencegah tidak termanfaatkannya bahan pakan yang tersedia dalam komunitas pertanian. Petani menyatakan bahwa kemudahan mendapatkan merupakan salah satu faktor yang menentukan dalam pemilihan bahan pakan walaupun mereka juga mempertimbangkan faktor kualitas bahan pakan. Petani cenderung untuk menggunakan bahan pakan berkualitas baik sebagai bahan pakan. Pada kedua desa yang diteliti, sistem pemberian pakan maupun populasi ternak yang ada didapatkan seimbang dengan sumberdaya yang tersedia. Produksi ternak secara biologis hanya dapat ditingkatkan dengan meningkatkan ketersediaan bahan pakan berkualitas tinggi.

Penelitian ini menunjukkan bahwa petani di kawasan lahan kering marjinal efisien dalam batas-batas teknologi yang tersedia. Perubahan-perubahan kecil dalam hal tatalaksana pemeliharaan seperti kontrol endoparasit, pemberian pakan berkualitas baik untuk sapi bunting atau laktasi serta penanaman lebih banyak gliricidia dapat memperbaiki produksi ruminansia. Tetapi adopsi dari inovasi itu mungkin terhambat oleh faktor-faktor sosial ekonomi seperti sulitnya re-alokasi sumberdaya tenaga kerja dan dana serta faktor pemilikan sumberdaya serta hasil produksi. Inovasi yang komplek yang memerlukan perubahan secara dramatis seperti introduksi sapi perah atau pola penggemukan sapi harus menghadapi faktor pembatas sumberdaya fisik dan ekonomi. Inovasi dengan resiko tinggi harus terlebih dahulu diuji memakai dana dari luar sebelum direkomendasikan kepada petani kecil. Petani, disisi lain, perlu mendapatkan informasi tentang alternatif tatalaksan produksi. Introduksi praktek tatalaksana yang baru, dapat memanfaatkan kenyataan bahwa petani pada dasarnya mengklasifikasi, memilih, improvisasi dan menyesuaikan teknologi sesuai dengan kemampuan mereka.

Model-model simulasi adalah alat yang berguna untuk mempelajari pola pemberian pakan ataupun evaluasi teknologi baru. Namun harus diingat bahwa hasil simulasi tergantung pada akurasi data sebagai inputnya. Data yang akurat dalam sub-sistem peternakan tidak dapat dikumpulkan melalui survai singkat. Untuk mendapatkan data semacam itu, diperlukan waktu dan usaha tenaga kerja yang relatif tinggi disertai usaha menciptakan hubungan yang erat dengan petani. Pekerjaan bersifat lintas disiplin seringkali memerlukan kompromi dalam hal, misalnya kriteria sampel, namun hal ini dapat memberikan pengertian yang lebih baik tentang sistem rumahtangga tani yang komplek serta keluwesan ternak dalam menunjang kesejahteraan. Tim peneliti lintas disiplin sangat diperlukan untuk usaha pengembangan wilayah.

CURRICULUM VITAE

The author of this thesis was born on April 15, 1956 in the city of Surabaya, Indonesia. He graduated from high school in Surabaya (SMA III) in 1975. In the same year he entered the Faculty of Animal Husbandry of Brawijaya University, Malang. He studied with a scholarship from the Directorate General of Higher Education of Indonesia. In 1981 he completed his studies and received the degree of Ir. in Animal Husbandry.

Since 1983 to now he is a staff member of the animal nutrition section of the same faculty and primarily responsible for the development and lecturing of subjects related to forage production and utilization. Apart from lecturing, he is active in research and public service, related to the above mentioned subjects. The Rector of Brawijaya University appointed him as a member of the nucleus team of the INterdisciplinary RESearch (INRES) Project in the Research Centre of the University in 1991. In early 1996, INRES merged with the Centre for Research on Village Area Development. From 1994 to now, he also holds a postion in the Postgraduate Faculty of Brawijaya University as lecturer on integrated farming systems. As part of his public service activities, he joined a team of agricultural consultants working for the Planning Institute of the Government of East Java in 1996.

In 1983, he was selected to do a six months individual training course at the Department of Crop and Forage Production (Vakgroep Landbouwplantenteelt en Graslandkunde) of Wageningen Agricultural University, sponsored by NUFFIC (Netherlands Universities Foundation for International Cooperation). During this study period, under the guidance of Prof. Dr. Ir. L.'t Mannetje, he became interested in matching the supply and demand for forages in mixed agricultural systems. In 1990, after spending a two year study period in Australia, sponsored by the International Development Program of Australian Universities and Colleges (IDP), he got his Master of Agricultural Studies (MAgrS) degree from the Melbourne University. His MAgrS thesis discussed the opportunities for forage introduction within the matrix of land-use in a mixed agricultural area in East Java, Indonesia.

In May 1996 he was assigned the task of head of *Badan Pertimbangan Penelitian*, a research unit responsible for the development of research activities for the staff of the Faculty of Animal Husbandry, Brawijaya University.