FEED RESOURCES AND SMALL FARM SYSTEMS IN ASIA *

by

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ABSTRACT

The Asian region accounts for 96.9% buffaloes, 29.4% cattle, 55.5% goats, 28.3% sheep, 46.6% pigs, 37.8% chicken and 64.8% ducks of the total world population. The annual rates of growth over the last ten years were 0.9% for buffaloes, 0.8% for cattle, 1.0% for goats, 1.0% for sheep, 1.5% for pigs, 14.0% for poultry and 1.4% for ducks. The prevailing ruminant production systems, classified according to intensity of production, are extensive systems, systems combining arable cropping (roadsides, tethering and cut-and-carry systems) and systems integrated with tree cropping. These are diverse and result from the interaction between ecological and socio-economic factors. Cattle have received special emphasis, but buffaloes, goats, sheep and ducks merit priority in development programmes. Generally, low productivity is a common feature with all ruminants including draught capacity in buffaloes and cattle. Land is the principal limiting factor, but the overriding constraint is animal feed in which quantity available and dietary protein are critical for all phases of animal production. The strategies for development must address the two principal issues of increasing feed supplies from available land and more intensive use of the total feed resources including non-conventional feeds all the year round in efficient feeding systems that are consistent with maximum offtakes from the animal resources. Potentially beneficial improvements to fibrous feeds can be achieved through physical, microbial and chemical treatments in which urea-ammonia appears promising and by supplementation with leguminous forages, but wider application of the available knowledge is dependent on cost effective demonstration of the results in real farm situations. More intensive utilisation of the herbage under tree crops (coconuts, oil palm and rubber) can substantially increase the productivity from ruminants. The search for efficiency in the utilisation of the feed resources calls for more innovative ruminant production systems that are demonstrably more profitable in Asia.
I INTRODUCTION

Maximising the productivity and contribution from the animal genetic resources in small farm systems depends to a very large extent on two principal factors. One concerns the availability of the total feed resources and the other, the efficient utilisation of these in effective feeding systems. Presently, it is extremely doubtful that animals within small farm systems do have adequate access to and benefit from both these aspects. Indeed, the present level of productivity is generally low and this is dictated almost entirely by continuing inefficient feeding and management.

The justification for increased attention to the importance of more complete use of the feed resources is also necessitated by the increasing size of animal populations, the pressure on available land for producing additional feeds and inability to grapple with these expanding problems in a manner that is consistent with making efficient use of the available resources (land, labour and capital) to ensure maximum offtakes from the animal resources. In an extreme situation, and looking far into the future, it is conceivable that lack of control over numbers, inability to allocate resources to support them and organise appropriate marketing may have serious effects on the environment.

Nevertheless, the importance of animals to the economy of small farm systems in Asia, justifies an appropriate and timely focus and examination of the feed resource base to support the animal populations. Appropriate because of continuing inefficiency, generally poor performance of animals and their inadequate contribution; timely because unless steps are quickly taken to equate feed adequacy with requirements, full use of the potential value of individual species is unlikely to be made and so also their economic value to several millions of small farmers in Asia. The intent in this paper is to examine available feed and animal genetic resources in small farm systems, and discuss strategies that are likely to have a greater impact on ensuring increased contribution from them.
II  THE ANIMAL RESOURCES

In Asian small farm systems, both ruminants and non-ruminants are found. Table 1 summarises the magnitude of individual populations in Asia. Of these, ruminants (buffaloes, cattle, goats and sheep) are generally more widely reared than non-ruminants, simply because of the long standing tradition of rearing these animals. They constitute renewable resources, have multiple functions (mainly draught, meat, milk and fibre) and also the ability to utilise the fibrous feed resources more completely than do non-ruminants. Their value is demonstrated by the fact that about 97%, 29%, 56% and 28% of the total world population of buffaloes, cattle, goats and sheep respectively are found in Asia (F.A.O., 1984).

(Table 1).

In terms of meat production, buffaloes, cattle, goats and sheep in Asia produced 85.2%, 6.0% and 29.1% of total world production (table 1). However, despite the relatively high ruminant populations and their individual contribution, the development especially of buffaloes and goats, and to a lesser extent sheep has been generally neglected. Development strategies have tended to concentrate principally on cattle, implying that the other species warrant much more emphasis in the future.

A long term analysis of the demand-supply situation by Simpson (1981) indicated that increased supply is not anticipated, and that the per capita consumption of beef, veal and buffalo meat will remain static or decline. Thus, the increase in consumption of animal proteins is expected to come from dairy products, goat meat and mutton, pig meat, poultry meat and eggs and imports (De Boer, 1982).

By comparison, the pig and poultry industries constitute advanced animal industries in many countries in Asia. The main reasons for this are associated with the availability and successful transfer of proven technology in pig and poultry production, the ease of
importing feedstuffs for them and the rapid turnover of capital investment. They have assumed industrial proportions and are usually found in urban-fringe areas which can absorb the growing domestic market outlets for the products. The long term viability of these intensive production units remains to be assessed.

Table 2 is a classification of the prevailing animal-based small farm systems in Asia. For each species, the production objective in relation to type of mixed cropping system is indicated. In the last column of the table, the current importance of the system is assessed in terms of a high, medium or low rating. The rating is based on animal ownership. In some countries, notably India, beef is relatively unimportant and the table does not adequately reflect its low rating there. Some other exceptions may also be found, but overall, the table does provide an adequate summary of the current position for the vast area of Asia.

(Table 2).

The main conclusion that emerges from this table is that among ruminants, buffaloes and cattle are of medium to high importance, whereas goats and sheep are of medium to low importance. Among non-ruminants, pigs, poultry and ducks, are all of medium to low importance in small farm systems.

III SIGNIFICANCE OF ANIMAL OWNERSHIP

Animals in small farm systems are seldom raised with a single objective in mind. Their ownership in small farms serve the material, cultural and recreational needs of the farmers. Thus, rearing animals have the following advantages:

(i) **Income** - important means of earning supplementary income.

(ii) **Employment** - creation of employment in animal industries.
(iii) **Security** - sources of investment, security and stability.

(iv) **Power** - source of farm power.

(v) **Food** - provide valuable animal proteins (milk and meat) that are important for nutritional well-being.

(vi) **Fertiliser** - contribution to farm fertility by the return of dung and urine.

(vii) **Fuel** - in some countries, buffalo and cattle dung are used as fuel.

(viii) **By-product utilisation** - with ruminants, they enable economic utilisation of non-marketable crop residues.

(ix) **Social values** - dairy development and the ownership of buffaloes have been shown to increase cohesiveness in village activities.

(x) **Recreation** - socio-economic impact of animal ownership also includes a recreational contribution to small farmers.

These advantages are reflected in the findings of a survey in rural India (N.S.S.O., 1970 - 1971). The survey showed that roughly 45 - 55% of the farm households were engaged in livestock activities (table 3). Within the livestock activities, dairying (from buffaloes, cattle and goats) was predominant (24.8 - 28.6%), followed by poultry production (12.9 - 16.9%).

(Table 3).
IV THE FEED RESOURCES

1. Adequacy and Requirements

The question of adequate feed resources to support the requirements of the total animal genetic resources represents a major challenge to animal nutritionists in all countries. The Asian region is unique in that this situation varies from one of acute inadequacy to adequacy in some countries. While all animal species are involved, the problem is more acute for lactating ruminants with their demand for more nutrients (Devendra and Wanapat, 1985).

The problem is acute in Asia where the feed requirements by livestock are in excess of current supplies. Recent analyses of the feed resource base in Asia in terms of the area under pasture and fodder crops, quantities of available feed grains, oil cakes and agricultural by-products, suggest a quantitative and qualitative insufficiency of feeds in relation to the total requirements for growth, reproduction and production of the livestock sector (Verma, 1983).

The situation is exemplified by India where it has been estimated that there was a shortage of 8.5 million tonnes of concentrates (44%), 38.4 million tonnes of dry fodder (11%) and 129.4 million tonnes of green fodder (38.4%) for dairy animals. The National Commission on Agriculture (1976) report also indicated that only 70% of digestible crude protein (DCP) requirement of dairy animals, 50% of the requirement of dry animals, 40% of the requirement of adult cattle and about 20% of the requirement of young cattle were being met from the available feeds. This situation has been projected to continue till the turn of the century (National Commission on Agriculture, 1976).

A similar situation also exists in Pakistan where despite the availability of $14.2 \times 10^6$ tonnes of total digestible nutrients
(TDN) and \( 1.4 \times 10^6 \) tonnes of crude protein, there is still a deficit of 49% energy and 42% digestible crude protein (DCP).

Although feed shortages are apparent in India and Pakistan, in some countries, such as in Malaysia (Devendra, 1982) or Sri Lanka (Ranjhan and Chadhokar, 1984), the feed resources are in excess of the requirements of farm animals (Devendra, 1982). A similar situation may also prevail in other super humid countries in South East Asia.

One aspect of the feed resources that is under-utilised in Asia concerns non-conventional feed resources (NCFR). Table 4 summarises the total availability from field and plantation crops in Asia and the Pacific. The generation of NCFR is very much higher than these figures suggest as the calculated availability does not include production from a variety of other field crops, data for which are not available in the statistics (FAO, 1982). Additionally, there are also residues and wastes from animal sources and the processing of food for human consumption which have not been included. Finally, there also exists an abundant variety of tree fodders that are used for feeding ruminants which have not been included.

(Table 4).

2. Crop Residues and Agro-industrial By-products

The Asian region as a whole is endowed with a vast reservoir of various crop residues and agro-industrial by-products, including NCFR. Lignocellulosic feed materials are found in every farm, but by-products from post-harvest processing and agro-industries are much less evenly distributed. It is significant to note that in Asia and the Pacific, the estimated total annual availability of these materials from both field and tree crop calculated from F.A.O. (1982a) was \( 1.298 \times 10^6 \)mt (table 4). Of these, approximately 83% are roughage materials that are particularly well suited for use by ruminants in efficient feeding systems. Cereal straws form a high
proportion of the available feeds and South and South East Asia alone produce about 93% of the world output of rice straw. The agro-industrial by-products are of three categories:-

(i) energy rich by-products from bananas, citrus fruits, pineapple, sugarcane and root crops (eg. banana waste and molasses).

(ii) protein supplements such as oilseed cakes and meals, animal by-products, by-products from the food industries and fishmeals (copra cake and feather meal).

(iii) by-products from cereal milling and palm oil refining (rice bran and palm oil mill effluent).


A historical sweep of the situation concerning crop residues and agro-industrial by-products utilisation in the Asian region leads to the following observations:-

(i) There now exists substantial and adequate information on quantitative and, to a lesser extent, qualitative data on individual feeds in most countries excepting those in the South Pacific. Tables of feeding value exist in a number of countries (eg. India, Thailand, Malaysia, Indonesia and the Philippines).

(ii) Many of the feeds are common to most countries and variations in nutritive value are normal and attributable to locational differences. Demonstration of effective utilisation in one country can enable application in another without recourse to expensive duplication or repetition of previous effort.
(iii) Research programmes in most countries tend to focus mainly on the utilisation of fibrous materials, especially cereal straws. The bulk of these have been concerned with the various options to use one or more alkalis (Doyle, 1982) without inadequate reference to cost-benefit effects.

(iv) The present position is that urea-ammonia treatment is the most promising chemical treatment technique. A parallel innovation is the use of urea-molasses block licks.

(v) Very few studies have attempted to utilise fibrous feeds in the untreated form in combination with other ingredients. There is evidence in this context that supplementation with leguminous forages may be just as effective and more cost-effective than chemical pre-treatments.

(vi) The bulk of work done hitherto has been at the laboratory or station level. Only limited effort has been made to extend these to site-specific and real farm situations, notably in Bangladesh, India, Pakistan, Sri Lanka and Thailand. These extensions are in any case small scale and not altogether convincing.

(vii) The opportunities for much wider application of nutritional principles that can ensure more efficient utilisation of crop residues and agro-industrial by-products especially in real farm situations are enormous, and need to be substantially expanded if ruminants are expected to make a bigger impact on current production.
4. Consequences of Inefficient Nutrition

The feed resource situation is such that indigenous animals are seldom encouraged to express their genetic potential. Additionally, given the present trend to distribute and make available a variety of improved germ plasm in all countries without exception, their failure and breakdown are increasingly apparent simply because of the inability of the small farm systems to accommodate the demand for more dietary nutrients and also improved management.

There exist several examples of studies that clearly demonstrate the consequences of inadequate nutrition and poor feeding management, manifesting in poor performance and reduced productivity. The following three examples forcefully demonstrate this point:-

(i) India (on Goats)

A comparison of weaner kids in the semi-arid environment of Rajasthan either browsing, browsing and forage, browsing and concentrates or browsing and forage and concentrates increased daily weight gain by between 115 to 458% and dressing percentage by 2.5 to 3.4%. Table 5 summarises the results.

(Table 5).

(ii) Malaysia (on Cattle)

A comparison between data from rural and stall-fed experimental animals at maturity showed significant differences in improvement due to improved feeding management. These differences were 64.0% in live weight at slaughter, 96.7% in hot-carcass weight, 7.2% in dressing percentage, 103.4% in weight of meat, 20.0% in meat : bone ratio and 118.8% in loin (Grade 1 cut);
Table 6 summarises these results from Devendra and Wan Zahari (1977).

(Table 6).

(iii) Indonesia (on Buffaloes)

A study on 35 cows in poor body condition weighing about 275kg and showing no ovarian activity were allotted to a high or low plane of nutrition for 30 weeks. At the end of this period, 17 of the 18 cows in the high plane of nutrition commenced ovarian activity whereas 10 out of the 17 in the low plane of nutrition did the same (Putu et al, 1983).

V RUMINANT PRODUCTION SYSTEMS

Present ruminant production systems in South and South East Asia and the Pacific which have endured in response to the total availability of land, pattern of crop production, frequency of cropping, area of uncultivated waste land and the density of animal populations have been classified (Mahadevan and Devendra, 1985) in the following categories:-

1. Extensive systems
2. Systems combining arable cropping
   i) Roadside, communal and arable grazing systems
   ii) Tethering
   iii) Cut-and-carry feeding
3. Systems integrated with tree cropping.

1. Extensive Systems

This system is by far the most common for all ruminants throughout the Asian region. It is characterised by ruminants,
usually owned by small farmers, grazing on all available grazing areas, largely uncultivated, including marginal land, for varying periods during the day. The length of the grazing period is dictated largely by the type of ruminant and the objectives of production: meat or milk.

The system has certain very definite features. Rearing ruminants is secondary to crop production, consistent with the pattern of agriculture. Usually, more animals tend to be carried than in the intensive system, probably because of the fact that these animals have access to plenty of grazing land. Buffaloes and cattle tend to be grazed separately, but where goats and sheep are reared, these small ruminants are grazed together probably because goats tend to lead the herd. Additionally, the small ruminants tend to be herded over longer distances compared to buffaloes and cattle which are relatively more sedentary.

In the extensive system, a low level of unpaid family income represents the main input. By implication, the use of this unpaid family labour, usually women and children, represents an aspect of effective labour use whereby both cropping and also rearing of ruminants represent important components of farm income. Except for the use of this low labour input, the system is principally one of low resource use, and a generally low level of productivity emerges from sub-standard nutritional management whereby very little or no concentrates, salt or mineral licks are provided, except in the case of dairy cows.

2. Systems Combining Arable Cropping

Ruminant production systems combining arable cropping have been evolved in situations where crop production is important to contribute to the stability of the system. Animals do not compete for the same land and play a supplementary role to arable cropping. Three types of systems are common as follows:-
i) roadside, communal and stubble grazing
ii) tethering, and
iii) cut-and-carry feeding.

The three are not mutually exclusive. Grazing on roadsides and on communal (waste) land may be practised by landless stock owners as well as others when their privately owned lands are under arable crop cultivation. Grazing in rice fields is restricted to periods immediately after harvest when the feeds available consist of the aftermath of the rice crop (viz. rice stubble and some regrowth from the stubble), any weeds which grow in the paddies, the grasses that are found on paddy bunds, and browse from shrubs and trees that grow in it. Where multiple cropping is practised, the crop aftermath may be burnt after the harvest and stubble grazing may be severely restricted or non-existent.

Tethering is adopted when there is a need to prevent animals wandering into areas being cropped and also to ensure that they graze down the available feed in a given area before they are moved. This type of confinement feeding is most popular in South East Asia because multiple cropping is very widespread in this region. The animals may be tethered on waste grazing areas close to the farm or on rice fields after harvest to regulate stubble grazing or close to stacks of rice straw to allow self-feeding.

In the cut-and-carry system a large proportion of the feed is usually brought in from outside the holding because of the small size of holdings in relation to the number of animals kept. The system is subject to the vagaries of seasonal abundance and shortage of forage that characterise it. Since the livestock are housed most of the time, this results in a growing dependence on high priced concentrate feeds during lean periods.

The system together has had limited success because of the value of arable land for food production. This also presents a constraint to forage production for animals. On the other hand, the emphasis on crop production makes available large quantities of crop residues which are valuable as feeds especially to ruminants.
3. Systems Integrated with Tree Cropping

Although this system can be described under the intensive arable system, it merits separate treatment especially in view of the area under tree crops (coconus, oil palm and rubber) in South and South East Asia and the South Pacific. More particularly, this is also justified by the fact that the system has considerable future potential in increasing production from ruminants (Devendra, 1985b) in view of the expanding hectarage under these tree crops.

This system is especially common in the humid and sub-humid regions where there is intensive crop production. Although the system is not new, integration with these tree crops to ensure more complete utilisation of the land has not been given adequate attention. The advantages of the system are:-

i) increased fertility of the land via the return of dung and urine,
ii) control of waste herbage growth,
iii) reduced use of weedicides,
iv) reduced fertiliser wastage,
v) easier management of the crop and
vi) distinct possibilities of increases in crop yields, consistent with greater economic including sale of animals and their products.

An additional advantage inherent in the system is the presence of abundant shade offered by the trees. This creates an environment which reduces heat stress on the grazing animals.

VI. FUTURE TRENDS

In cognisance of the prevailing patterns of animal production and the resources currently being used to support them, it has been
concluded that ruminant production systems are unlikely to change (Mahadevan and Devendra, 1985). It is the view of these authors that major shifts in resource use would be difficult to achieve unless returns from the new systems proposed are demonstrably superior. Changes must therefore, be introduced gradually and must ensure income stability and low risk. The principal aim should be to make maximum use of the basic feed resources available, which is essentially crop residues and/or low quality roughages. In addition, delivery systems should be developed for the essential supplementary feeds (leguminous forages, agro-industrial by-products or other feed concentrates).

Given these considerations, the following strategies are considered to be the more appropriate and also the ones that are most likely to respond to successful technological and economic interventions concerning the efficient utilisation of the feed resources. The strategies also take into consideration more efficient utilisation of the available production resources.

1. Crop Residues and Agro-industrial By-products

More intensive use needs to be made of large amounts of lignocellulosic materials and other agro-industrial by-products, simply because these are the cheapest and most widely available feeds for ruminants. This conclusion has also been previously emphasised (F.A.O., 1982b; Mahadevan, 1982). For successful application, acceptable feeding systems are those that are simple, practical, within the limits of farmers' capacity and resources availability, convincing and consistently reproducible. Moderate to low levels of animal performance may be biologically inefficient, but could be more economically viable than high levels of performance especially with existing limitations of small farm systems. This is illustrated in Table 7 in a comparison between annual feed calorie balance between buffaloes subjected to a feeding regime based on cultivated forage and concentrates and those fed alkali-treated straw, agro-industrial by-products and
non-protein nitrogen.

(Table 7).

2. Integrated Ruminant-Tree Crops Systems

The integration of individual ruminants with tree crops (coconut, oil palm and rubber) represents a potentially important means of increasing substantially, current production from them. Although interest in this production system is increasing, much more can be done to utilise more completely the available herbage under crops in all countries. In the Solomon Islands and Western Samoa, it has been reported that between 48% and 60% of the national beef herds were found in coconut plantations (Quartermain, 1981), but a parallel situation may not exist in other countries.

The age of the crop at which ruminants can be integrated is an important issue to avoid damage to young plants. Equally important is knowledge of the dry matter yields from forages available under the tree crops to equate this to optimum stocking rates. Other considerations include feeding behaviour, choice of species, availability of animals, relative price of meats and market outlets.

Evidence of the benefits and integrating ruminants with oil palm is reflected in recent data from Malaysia (Table 8). The case history concerns an oil palm estate which allocated a portion of the grazing land to the workers for grazing their cattle. For the first two years (1980 - 1981), only cattle were owned and grazed, and subsequently during 1982 and 1983 goats were introduced in addition to cattle. The comparison of the grazed area and non-grazed area is valid because the same sites were used and both were about 80 and 220 animals respectively.

Table 8 shows that the differences in yield favour of combined cattle and goat grazing was 2.15 - 5.16 mt fresh fruit
bunches/ha/yr, with a mean value of 3.51 mt of fresh fruit bunches/ha/yr. When related to the total hectarage and sale value of the oil palm yield, the advantage is substantial. Similar opportunities thus exist elsewhere to increase ruminant production from the land. In Malaysia for example, the total hectarage under oil palm and rubber is approximately 4.3 million. Even if only half of this crop area is utilised by ruminants, and assuming a stocking rate of 0.3 RLU/ha, the potential stocking capacity is of the order of $1.3 \times 10^6$ RLU.

(Table 8).

3. **Increased Forage Cultivation on Available Land**

A third avenue that can be intensifi ed is increased cultivation of forages, grasses and legumes on available land. This includes any waste or uncultivated land, rice bunds and fence lines. The use of leguminous forages like leucaena (*Leucaena leucocephala*) or sesbania (*Sesbania grandiflora*) is underestimated and very much more use can be made of these especially as supplements (Devendra, 1984). The former provides an excellent source of fodder and dietary nitrogen even during droughts and can also be used as a good fence line. The presence of such forage reserves form an important component of integrated agriculture in small farms and go a long way towards furnishing much needed nutrients to enhance animal performance.

The basic strategy is to produce sufficient amounts of feed of good quality that are available all the year round. On small farms, the demand for food crops supercedes production of feeds for livestock. Thus, innovative measures are needed for meeting nutrient requirements of livestock from various forages and residues from food crop production. This approach also has the associated advantage of enabling seasonal supluses for example, cereal straws or silages, to be preserved for use subsequently, when feeds are in short supply such as during the dry seasons and droughts.
Recent experience in Malaysia concerning forage cultivation on available land and the impact of the increased feed availability in an integrated dairy development system is worth mentioning. A case in point concerns a farmer whose main occupation was the cultivation of oil palm. When he was first encouraged to grow more fodder (mainly Napier grass and leucaena), he had four Sahiwal-Friesian cows. After three years of participation he took advantage of feeding the extra forage available as well as utilising oil palm by-products, as a consequence of which he expanded the operations to 40 milking cows. His earnings increased to about US$130 - 160/cow/month (Devendra, 1983b). Similar examples of successful operations are not uncommon elsewhere, provided feeds are sufficiently available to provide the basic stimulus for high performance and increased production.

4. **Strategic Use of Supplementary Protein Sources**

Strategic use of protein supplements, often the main limiting factor for all phases of animal production in efficient feeding and nutrition of ruminants, needs to be more widely encouraged than has been the case in the past. Leng and Preston (1983) have shown for example, that the direct financial benefits to developing country, in terms of milk produced per unit of foreign currency (or foreign aid) is considerable.

It is imperative therefore that protein concentrates like coconut cake, groundnut cake, soyabean meal, palm kernel cake and fish meal, all of which are found in most countries in the region are conserved and preferentially utilised. Some of these ingredients may even need to be protected for local use rather than be exported. Malaysia currently produces about 480,000 tonnes of palm kernel cake, about 95% of which are exported to Europe and unfortunately not available for home use. An important implication of this conservation is that scarce concentrates can be put to better use judiciously by ruminants and more efficiently by non-ruminants.
VII. CONCLUSIONS

Prevailing production systems in the Asian region are diverse and are influenced by numerous issues, especially those resulting from the interaction between ecological and socio-economic factors. Climate exerts a dominant influence and varies from arid and semi-arid to humid and super-humid conditions on traditional farming patterns which are characteristically integrated crops-livestock systems. The majority of the ruminant populations (buffaloes, cattle, goats and sheep) found in these systems are generally in low productivity and unable to keep pace with the demands of human nutritional needs. Land is a principal limiting factor, but the overriding constraint common to all production systems is animal feed.

The strategies for future improvements must therefore, address the primary question of increasing the quantity of feed supplies all the year round and more efficient utilisation of existing feeds, especially crop residues and agro-industrial by-products, including NCFR, through appropriate physical and/or chemical techniques and especially protein supplementation. There also exists enormous opportunities for more intensive use of the herbage under tree crops and strategic use of scarce concentrates. The final objective in all these strategies is the aim to ensure that complete utilisation of the animal resources is compatible with efficient production systems and consistent with maximum contribution from livestock.
REFERENCES


### Table 1

The animal resources of Asia and their relative contribution (F.A.O., 1984)

<table>
<thead>
<tr>
<th>Species</th>
<th>Population (millions)</th>
<th>As % of world population</th>
<th>Rate of growth/yr (%) (1974-76 to 1984)</th>
<th>As % of world production</th>
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<tr>
<td></td>
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<tr>
<td>Buffaloes</td>
<td>122.2</td>
<td>96.9</td>
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<td>Cattle</td>
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<td>Goats</td>
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<td>Sheep</td>
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<td>Chicken</td>
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<td>37.8</td>
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<td>20.3</td>
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<td>Ducks</td>
<td>103.0</td>
<td>64.8</td>
<td>1.4</td>
<td>-</td>
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</table>

Notes: - indicates no data available.
### TABLE 2

**ANIMAL-BASED SMALL FARM SYSTEMS IN ASIA**
(Devendra 1983a)

<table>
<thead>
<tr>
<th>Species</th>
<th>Production objective</th>
<th>Type of mixed cropping system</th>
<th>Current importance++</th>
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<tr>
<td><strong>I. Ruminants</strong></td>
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<tr>
<td>Buffaloes</td>
<td>Beef</td>
<td>Rice cultivation</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Draught</td>
<td>Rice &amp; field crops cultivation</td>
<td>High</td>
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<td></td>
<td>Milk</td>
<td>Orchards+ &amp; wheat cultivation</td>
<td>High</td>
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<td>Cattle</td>
<td>Beef</td>
<td>Orchards, tree crop plantation, rice cultivation</td>
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<td>Dairy</td>
<td>Orchards &amp; tree crop plantations</td>
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<td>Draught</td>
<td>Rice &amp; field crops cultivation</td>
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<td>Orchards &amp; tree crop plantations</td>
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<td>Sheep</td>
<td>Mutton</td>
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<td><strong>II. Non-ruminants</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pigs</td>
<td>Meat</td>
<td>Intensive vegetable production &amp; orchards</td>
<td>Medium/High</td>
</tr>
<tr>
<td>Poultry</td>
<td>Meat/Eggs</td>
<td>Orchards &amp; intensive vegetable production</td>
<td>Medium/Low</td>
</tr>
<tr>
<td>Ducks</td>
<td>Meat/Eggs</td>
<td>Orchards, rice cultivation &amp; coastal fishing</td>
<td>Medium/Low</td>
</tr>
</tbody>
</table>

+ Includes gardens and unused potentially valuable land
++ Based on ownership by small farmers
<table>
<thead>
<tr>
<th>Activity</th>
<th>Small cultivator households</th>
<th>Non-cultivator wage-earner households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock</td>
<td>41.6 (92%)</td>
<td>50.3 (92%)</td>
</tr>
<tr>
<td>Dairying</td>
<td>24.8</td>
<td>28.6</td>
</tr>
<tr>
<td>Poultry</td>
<td>12.9</td>
<td>16.9</td>
</tr>
<tr>
<td>Other animal production</td>
<td>3.9</td>
<td>5.8</td>
</tr>
<tr>
<td>Other ancillary activities</td>
<td>3.4 (8%)</td>
<td>4.3 (8%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>45.0</strong></td>
<td><strong>54.6</strong></td>
</tr>
</tbody>
</table>
TABLE 4

THE AVAILABILITY OF NON-CONVENTIONAL FEED RESOURCES IN ASIA AND THE PACIFIC (Devendra, 1985a)

<table>
<thead>
<tr>
<th>Category</th>
<th>Availability (10^6 tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field crops</td>
<td>189.9</td>
</tr>
<tr>
<td>Tree crops</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Total         | 194.1⁺

⁺ Represents 44.9% of the total availability from field and plantation crops.
TABLE 5

PERFORMANCE OF WEANER KIDS IN A SEMI-ARID ENVIRONMENT IN INDIA
(Parthasarathy, Singh and Rawat, 1983)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Browsing (B)</th>
<th>B + forage</th>
<th>B + concentrates</th>
<th>B + forage + concentrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight(kg)</td>
<td>12.0</td>
<td>10.9</td>
<td>12.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Final weight(kg)</td>
<td>13.8</td>
<td>14.7</td>
<td>22.8</td>
<td>22.3</td>
</tr>
<tr>
<td>Weight gain(kg)</td>
<td>1.8</td>
<td>3.7</td>
<td>10.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Av. daily gain(g)</td>
<td>19.4</td>
<td>41.7</td>
<td>111.0</td>
<td>108.2</td>
</tr>
<tr>
<td>Dressing %</td>
<td>45.7</td>
<td>44.5</td>
<td>48.2</td>
<td>49.1</td>
</tr>
<tr>
<td>Net returns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Rs/kid/90 days)</td>
<td>-</td>
<td>9.0</td>
<td>3.6</td>
<td>0.2</td>
</tr>
</tbody>
</table>
TABLE 6

MAGNITUDE OF IMPROVEMENT FEASIBLE IN CATTLE FROM RURAL AREAS DUE TO IMPROVED NUTRITIONAL MANAGEMENT IN MALAYSIA (Devendra and Wan Zahari, 1977)

<table>
<thead>
<tr>
<th>Parameter of economic significance</th>
<th>Rural cattle (24 months)</th>
<th>Experimental cattle (22 months)</th>
<th>% improvement feasible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight at slaughter (kg)</td>
<td>122.5</td>
<td>200.9</td>
<td>64.0</td>
</tr>
<tr>
<td>Hot carcass weight (kg)*</td>
<td>54.3</td>
<td>106.8</td>
<td>96.7</td>
</tr>
<tr>
<td>Dressing %</td>
<td>46.1</td>
<td>53.3</td>
<td>7.2</td>
</tr>
<tr>
<td>Weight of meat (kg)</td>
<td>43.3</td>
<td>88.3</td>
<td>103.9</td>
</tr>
<tr>
<td>Meat as % of carcas weight (%)</td>
<td>77.4</td>
<td>82.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Meat : bone ratio</td>
<td>4.5</td>
<td>5.4</td>
<td>20.0</td>
</tr>
<tr>
<td>Loin</td>
<td>8.3</td>
<td>15.8</td>
<td>118.8</td>
</tr>
</tbody>
</table>

* Based on slaughter weight.
**TABLE 7**

**NET ANNUAL FOOD CALORIE BALANCE RESULTING FROM THE ADOPTION OF TWO DIFFERENT FEEDING REGIMES TO MILCH BUFFALOES**

(Mahadevan, 1977)

<table>
<thead>
<tr>
<th>Feeding regime</th>
<th>Annual milk production (kg)</th>
<th>Input (Mcal)</th>
<th>Output (Mcal)</th>
<th>Balance (Mcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated forage from 1/6 ha + 600 kg concentrates fee/year</td>
<td></td>
<td>2800</td>
<td>5200</td>
<td>Milk 2200</td>
</tr>
<tr>
<td>Alkali-treated straw (8-10kg/day) + 700 kg agro-industrial by-products + NPN + minerals</td>
<td></td>
<td>1400</td>
<td>3000</td>
<td>Milk 1500</td>
</tr>
</tbody>
</table>
### TABLE 8

THE EFFECT OF MIXED CATTLE AND GOAT GRAZING ON THE YIELD OF FRESH FRUITS IN OIL PALM CULTIVATION IN MALAYSIA

(Devendra, 1985b)

<table>
<thead>
<tr>
<th>Year</th>
<th>Grazed area (Yield of fresh fruit/ha/yr, mt)</th>
<th>Non-grazed area (Yield of fresh fruit/ha/yr, mt)</th>
<th>Difference (Fresh fruit/ha/yr, mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>30.55 (C)†</td>
<td>25.61</td>
<td>4.94</td>
</tr>
<tr>
<td>1981</td>
<td>17.69 (C)†</td>
<td>15.87</td>
<td>1.82</td>
</tr>
<tr>
<td>1982</td>
<td>25.12 (C + G)‡</td>
<td>22.97</td>
<td>2.15</td>
</tr>
<tr>
<td>1983</td>
<td>23.45 (C + G)†</td>
<td>18.29</td>
<td>5.16</td>
</tr>
<tr>
<td>Mean</td>
<td>24.20</td>
<td>20.69</td>
<td>3.51</td>
</tr>
</tbody>
</table>

† C - Cattle  
‡ C + G - Cattle + Goats