Executive Summary

The potential of small-scale dairy production to contribute to securing the livelihoods of millions of smallholder farm households in developing countries has been widely appreciated. On these farms, hired labourers from poorer households benefit from hand-outs of or payments in kind in milk as well as increased opportunities for earning cash. Marketing of the milk produced by small-scale enterprises allows wider access to cheaper dairy products amongst poorer consumers in both rural and urban areas. A key constraint to the development of smallholder dairy production lies in farmers' lack of access to reliable information on appropriate feeding strategies for the range of conditions that they experience during the course of a year. Unfortunately, the capacity of extension services to support their client farmers in planning effective feeding and management strategies for smallholder dairy cattle has been seriously limited in the past. This is largely because available extension material cannot help farmers to account for the complex and dynamic decision making that is needed for effective management. In particular, the paper-based extension literature available is not really accessible to extension staff with limited expertise in animal nutrition. This deficiency, and the development opportunity that it poses, have been addressed by this LPP research project (R6282: *Development of a Practical Dairy Feed Rationing System Appropriate for use in Developing Countries*).

DRASTIC – A Dairy Rationing System for the Tropics

Computer technology is becoming increasingly available in the local and regional headquarters of extension services, in the offices of technical support staff in dairy co-operatives and through dairy development projects. With the global information technology boom, this is a trend that is unlikely to be reversed in future. R6282 sought to capitalise on this trend to produce a computer software package that could be applied at these levels allowing extension and technical staff to provide effective decision support to farmers.

The system developed (DRASTIC), incorporates the biological relationships established by dairy nutrition research to provide a robust source of information for a wide variety of situations. DRASTIC has been carefully designed to be particularly suited to non-expert use in planning dairy feeding under tropical conditions. The following features are particularly important in this respect:

- The complex calculations required to describe the relationships between nutrient intake and levels of production are rapidly and accurately completed;
- DRASTIC can be used effectively with the patchy and unreliable information on feed quality that is usually all that will be available in a field situation;
- Simple quality indicators, readily assessable by farmers and extension staff, are used to cope with the high degree of variability seen in tropical feed quality;
- User-friendliness and accessibility to those with only limited experience of computers have been given the highest priority during the construction of DRASTIC.

The Potential of DRASTIC

DRASTIC has recently undergone field-testing with farmers and development project, dairy co-operative and national research and extension service staff during dissemination workshops conducted in Bolivia and Tanzania. This testing has suggested that the approach is robust (see Table) and that DRASTIC has been successful in packaging available information in a way that will stimulate day-to-day use in a practical situation. Therefore, the key objectives addressed by its development would appear to have been met.

Farmer	**Actual milk yield** (litres / day)	**Yield predicted by DRASTIC** (litres / day)
Eduardo	20	19.1
Fidel	15	15.4
Fito	8	8.2
Juan	12	9.9
Miguel	8	7.9
Oscar	8	7.9
Rosendo	15	14.5
Toto	8	7.4
Yapacani tecnico	8	7.3

Although basically a feed rationing tool, DRASTIC can, because of its interactive nature, be used, at several levels, to plan feeding strategies in response to many of the real management questions that arise from the dynamic nature of dairy production in the tropics. These might include:

- Responding to seasonal changes in pasture or forage availability and quality;
- Assessment of the impacts of changes in supplement availability;
- Assessment of the potential benefits of introducing new supplements into a region;
- Assessment of changes in cost benefits of supplementation with changing milk prices;
- Identification of break points resulting from changes in supplement prices.

Recommendations

The project has met all its objectives in delivering a simple, computerised, decision support tool for dairy rationing under field conditions in developing countries. Therefore, recommendations for follow-up work focus mainly on wider dissemination of DRASTIC and the provision of support for its continued development and use. Suitable sources of funding will be sought for:

- Holding a series of further dissemination workshops in other dairy producing areas of Bolivia (La Paz, Cochabamba, Sucre, Tarija). This is in response to a request from the President of CONBOPROLE (the Bolivian National Milk Producers Confederation);
- Holding a series of dissemination workshops in India;
- The development of an extension methodology and training pack for promoting the use of DRASTIC in association with extension – farmer study groups in east Africa (Tanzania and possibly Kenya);
- Modifying DRASTIC so that it can be used to generate dynamic, pictorial extension guides to assist farmers directly in altering their feed management strategies in response to changing circumstances (Talking Pictures);
- Supporting the wider dissemination of DRASTIC globally including the distribution and modification of the software and the establishment and maintenance of a DRASTIC Internet site over a three year period

These proposed activities have been formulated to promote the broad-based, sustainable dissemination of the DRASTIC software that will be required if this research programme output is to generate a genuine and lasting developmental impact.

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Background

Identification of Demand

The potential of small-scale dairy production to contribute to securing the livelihoods of millions of smallholder farm households in developing countries has been widely appreciated (Del Castillo, 1990; De Jong, 1996; ILRI / NARO / MAAIF, 1996). On these farms, hired labourers from poorer households benefit from hand-outs of or payments in kind in milk as well as increased opportunities for earning cash. Marketing of the milk produced by small-scale enterprises allows wider access to cheaper dairy products amongst poorer consumers in both rural and urban areas (MOAC / SUS / ILRI, 1998). A key constraint to the development of smallholder dairy production lies in farmers' lack of access to reliable information on appropriate feeding strategies for the range of conditions that they experience during the course of a year (Laurent and Centres, 1990). Unfortunately, the capacity of extension services to support their client farmers in planning effective feeding and management strategies for smallholder dairy cattle has been seriously limited in the past. This is largely because available extension material cannot help farmers to account for the complex and dynamic decision making that is needed for effective management. In particular, the paper-based extension literature available is not really accessible to extension staff with limited expertise in animal nutrition. This deficiency, and the development opportunity that it poses, have been addressed by the research project (R6282: *Development of a Practical Dairy Rationing System for the Tropics*) described in this final technical report.

Researchable Constraints

Current support to extension services in the delivery of extension advice on nutrition is generally based on static recommendations. Such recommendations are limited in that they cannot account for the diverse requirements of individual farmers or for the shorter term changes in resource access and requirements that characterise the background against which production decisions are, in fact, taken by farmers. In order to address this absence of appropriate support to practical rationing for smallholder cattle, the project needed to focus on two distinct issues:

- The suitability of current or improved biological descriptions of nutrient digestion and utilisation for application to smallholder cattle in the tropics;
- Appropriate means of packaging this information so that it may be used by support services to address the actual, practical problems experienced by farmers in the field.

At the project conception stage, it was envisaged that the first of these issues would probably require considerable attention. However, it became apparent to the course of the work described in this report that, for a practical rationing system, the means of delivery would be key. It was concluded that a biological approach based largely on existing knowledge would suffice as:

- Major errors in planning dairy cow feeding strategies would arise from inaccuracies in field assessments of feed quality and not from limitations due to the specification or estimation of parameters describing ruminal or post-ruminal digestion in a biological model.

- Adopting a genuinely bottom-up approach to the problem would require the substitution of currently available, static extension information with a more responsive and flexible decision support tool. In order to produce a practically useable tool, a focus on information availability in the field situation would be more appropriate than an approach based on information required by a "pre-specified" biological model.

Computer technology is becoming increasingly available in the local and regional headquarters of extension services, in the offices of technical support staff in dairy co-operatives and through dairy development projects. With the global information technology boom, this is a trend that is unlikely to be reversed in future. R6282 sought to capitalise on this trend to produce a computer software package that could be applied at these levels allowing extension and technical staff to provide effective decision support to farmers.

In order to ensure useability, the following features were specified for the system:

- The complex calculations required to describe the relationships between nutrient intake and levels of production should be rapidly and accurately completed and require only minimum inputs of quantitative data from the user;
- It should be possible to use the system effectively with the patchy and unreliable information on feed quality that is usually all that will be available in a field situation;
- Simple quality indicators, readily assessable by farmers and extension staff, should be used to cope with the high degree of variability seen in tropical feed quality;
- User-friendliness and accessibility to those with only limited experience of computers should be given the highest priority during the design and construction of the system's computer interface.

This specification has required the project to focus its research activities in the following areas:

- The development of object-oriented representations of farm livestock for simple simulation models;
- The identification of qualitative – quantitative relationships amongst parameters describing feed quality including the development of fuzzy logic based algorithms to depict these;
- The design of simple user interfaces for non-expert users.

Review of Literature

The Objectives of Rationing

The objectives of operating rationing systems for farm livestock may be stated, in general terms, as being:

> *To combine available feeds in a way that balances the nutrients in them to meet the livestock farmer's production objectives in the most efficient and cost-effective manner possible.*

However, there are a number of marked differences between industrialised and developing countries in the ways in which these objectives - and the constraints on achieving them - are defined in the first place. As a result, the most appropriate ways of packaging rationing systems a likely to differ considerably, hence the need for a rationing system designed specifically for dairy cows in the tropics.

Feeding and Rationing Systems in Industrialised Countries

The objectives of livestock keepers in industrialised countries are largely concerned with maximising the financial returns from the production of meat, milk, eggs, hides, skins and fibres. Feed availability and quality can be a constraint, particularly when fresh, green pasture is unavailable. However, conservation technologies and the purchase of supplementary feeds generally allow nutrient imbalances and their adverse effects on production levels to be minimised.

Supplementing feeds produced on the farm with purchased feeds means that the cost-benefits alternative feeding strategies is usually the most important consideration in rationing livestock to meet production objectives. Indeed, feed costs can account for more than 80% of variable costs on industrialised pig and 60% on dairy farms (Nelson, 1979). Within a particular region, feeding systems used on different farms in the Temperate Zone are generally similar to each other and use a relatively restricted number of feeds. Furthermore, the factors that lead to variation in the nutritional characteristics of these feeds have been relatively clearly identified. This has facilitated the use of rationing based on tables of nutritional compositions obtained from animal feeding trials and laboratory analysis. Thus, the rôle of conventional feed evaluation is to provide data for quantitative predictions of animal production using specific feeds within an established feeding system. This information can be used for quality control, to introduce new feeds and for the investigation of feed problems as well as for feed rationing. However, data on feed quality must generally be interpreted within the context of an appropriate feed evaluation or rationing system.

Feeding and Rationing Systems in Developing Countries

Constraints on livestock production in developing countries are generally very different to those encountered in more industrialised livestock production systems. Where it impinges on the livelihoods of the poor, livestock keeping is often closely integrated with other agricultural activities and may, therefore, have multiple objectives. For the poorer farmer, there is little cash available for the purchase of feeds from off-farm sources and, often, these are not available in any case. Therefore, feeding systems are much more dependent on absolute feed availability making approaches to rationing based on the targeting of product output levels difficult to implement.

Multiple production objectives that are also sometimes conflicting complicate the planning of appropriate feeding strategies. For example, Tanner *et al*. (1996) report the high priority placed on manure / compost production by goat keepers in the intensive crop-livestock systems of Java. Few rationing systems developed for temperate situations would be able to cope with this as an objective although Dewhurst and Thomas (1992) do illustrate the use of the UK metabolisable protein system for examining the implications of feeding for nitrogenous waste management.

Another major difficulty when planning rations for livestock production systems in developing countries is that of variability. This may result from the influences of many environmental, social and market-based factors and may be classified as follows:

- The quantity of feed material is highly variable. This may be a result of seasonal differences (e.g. Thorne *et al*., 1998) but also more local factors such as aspect, land-holding size, access to common property resources. As a result, the blanket recommendations on feeding systems that may be appropriate for temperate, industrialised systems in which feed availability is much more under the farmer's control are of limited use in developing countries. Different ethnic or other social groups may also experience different levels of access to feed and other resources (Thorne *et al*., 1998).
- The range of organic resources available to farmers in developing countries for use as feeds is often very large. For example, Blair (1990) lists some 270 species from 74 genera as being of potential value as fodder. Devendra (1992) cites a range of common tree genera used as animal feeds including acacia, calliandra, erythrina, ficuse, sesbania, gliricidia and leucaena. The nutritive values of a number of species from these genera have been relatively well researched. However, even within these relatively widely used genera this information is usually restricted to a limited number of species. Furthermore, many other species used widely by farmers have received little or no attention.
- Factors affecting the quality of individual tropical feeds are generally much more diverse than in temperate countries and under the control of the farmers to a much lesser extent.

The major consequence of this variability for practical rationing is that book values for feed quality are unlikely to be available and, where they are available it is often not possible to relate them to the particular instance of the feed being used. Any practical rationing system for the tropics needs to be able to counter this problem.

The full potential of a feed can only be realised when it forms part of a balanced diet. Leng *et al*. (1992) have suggested that growth and milk production of livestock in developing countries may amount to as little as 10 *per cent* of their genetic potential as a result of imbalances in nutrients, disease, parasitism, and climatic conditions. In developing countries constraints on feed availability and quality mean that balanced diets are unlikely to be achieved. A suitable rationing system must, therefore, be able to furnish "best-bet" recommendations for situations in which the availability of feed inputs is sub-optimal.

Components of Rationing Systems

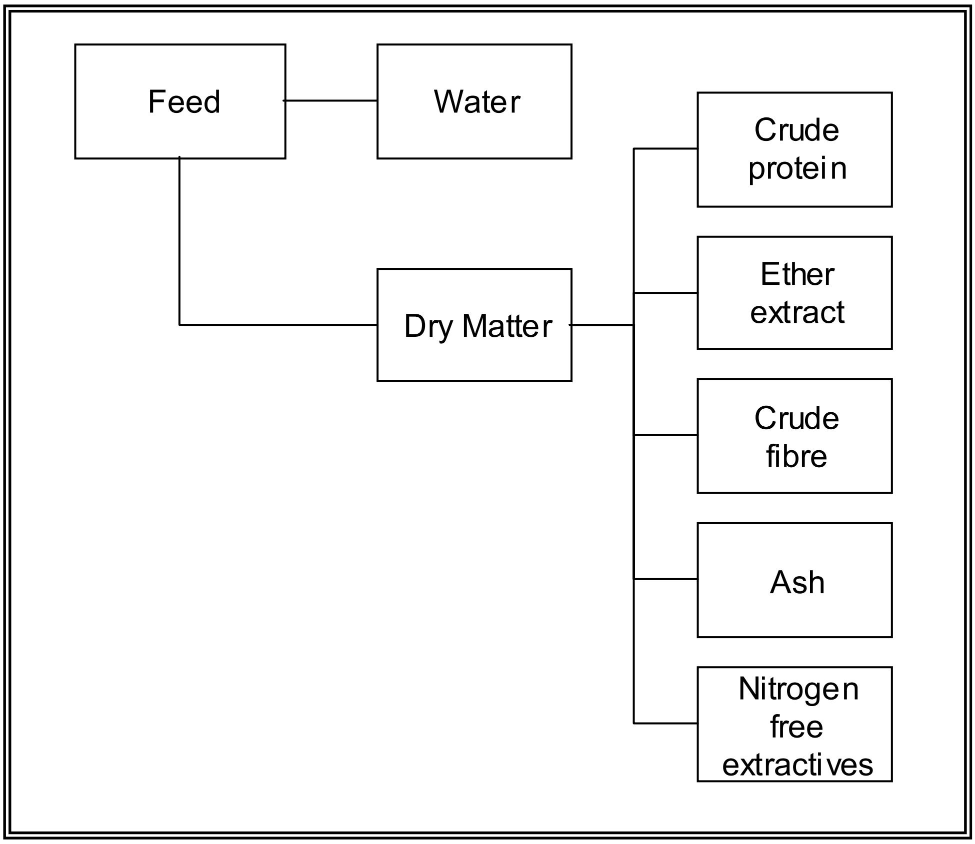
In order to ration farm livestock effectively, information is required on:

- The nutritional characteristics of the feeds that are available (feed characterisation)
- The responses in livestock production parameters to different patterns of nutrient supply.

Feed Characterisation

Feed characterisations for rationing livestock will vary with the type of system used. However, they will invariably include some estimate of the capacity of a feed or mix of feeds to supply protein (or nitrogen) and energy useable by the animal.

Figure 1: *Partitioning of feed nutrients by proximate analysis*.



Proximate Analysis

The system of proximate analysis (Figure 1) represents the earliest attempt at describing the nutritive value of feeds and was developed in Germany in the 19th century. Even today, proximate analysis can provide a useful, basic overview of the partitioning of feed nutrients into compounds that influence the delivery of protein and energy to the animal. However, the nutritional significance of the chemical indicators that make up a proximate analysis is far from precise and the impact of differences in them on animal performance can, therefore, be difficult to predict. Nevertheless, feed analysis continues to be based largely on the fractionation of feeds depending on the nutritional characteristics of their constituents. However, the methods used have become considerably more sophisticated, in particular in the extent to which they reflect the biological processes of digestion.

Chemical compositions of feeds are routinely used as a rapid and economical method for their characterisation. Chemical parameters may be used to predict digestibility and other measures of the nutritive value, provided that appropriate equations are available. Such equations may be based on statistical associations (that may or may not reflect causal relationships!) between the content of analysed constituents and feed quality (e.g. Van Soest, 1982). No single compositional parameter can adequately predict nutritive value across a range of feeds, although combining the results from several analyses may improve the robustness of predictions (Vadiveloo and Fadel, 1992).

These developments are discussed briefly below in relation to some of the most important nutritionally significant fractions of feeds.

Carbohydrates

Carbohydrates, including cellulose, starch and simple sugars are generally the most important energy-yielding compounds in ruminant diets. In the proximate analysis system, the carbohydrate component of feed is partitioned between two fractions; the crude fibre and the nitrogen-free extract. When the sum of the amounts of moisture, ash, crude protein, ether extract and crude fibre (expressed in g/kg) is subtracted from 1000, the difference is designated the nitrogen free extract (NFE). The crude fibre fraction contains cellulose, lignin and hemi-cellulose. However, these substances are not necessarily present in all feeds. Furthermore, a variable proportion of them is also contained in the nitrogen-free extract, depending upon the species and the stage of growth of the plant material. Crude fibre was intended originally to provide a measure of the indigestible part of the food. Nevertheless, ruminants may, in fact, digest a proportion of it.

The division of carbohydrate between NFE and CF has proved to be of limited use in predicting the extraction of nutrients by the animal. The detergent fibre scheme proposed by Van Soest, (1976) was developed as a more process based consideration of the fibre fraction of feeds and their consequences for energy delivery in the ruminant. The scheme has been critically reviewed and refinements have been developed which include further partition of the main components. The main modification aims to characterise the carbohydrate component more effectively by partitioning it into structural and non-structural pools. These are the acid detergent fibre (ADF), acid detergent lignin (ADL) and the neutral detergent fibre (NDF). ADF represents essentially the crude lignin and cellulose fractions of plant material, but also includes silica. NDF consists essentially of lignin, cellulose and hemicellulose and is regarded as a measure of the plant cell wall material. The determination of ADF is particularly useful for forage as there can be a good statistical correlation between this and digestibility. NDF can be a useful indicator of intake. However, in many cases chemical composition alone can be a poor indicator of parameters such as intake and in vivo digestibility. For example, Khazaal and ∅rskov (1993) found a significant ($P<0.05$) relationship between NDF and intake for ten hays but no other relationships between composition and either in vivo digestibility or intake. Non-structural carbohydrates are composed of sugars and starch, which can be a complex and variable mixture depending on the nature of the feed. Analysis of non-structural components is relatively complex and therefore not generally included in routine feed analysis.

Energy

Energy is required for the maintenance and productive outputs of animals and is released by the oxidative metabolism of nutrients absorbed from feeds. The total amount of energy, derived from the organic matter within a feed, is termed its Gross Energy (GE). In practice not all of this energy is available to the animal as losses occur via the faeces and urine and through the evolution of methane from fermentation processes. When these losses are accounted for, the proportion of the GE that may potentially be assimilated by the animal is obtained and is termed the Metabolisable Energy (ME). ME may be used for a variety of purposes by the animal; general maintenance; milk production, liveweight increases, maintenance of pregnancy, generation of draught power. However, the metabolic processes associated with energy utilisation in the animal involved are not completely efficient and their efficiency varies amongst end-uses. Efficiency factors have been estimate and ME supplies to the animal may be multiplied by the appropriate efficiency factor to assess the supply of Net Energy (NE).

Various energy rationing systems have been based on this theoretical outline to describe the amount of energy which ruminants can obtain from a feed and the use to which they can put, i.e., the relationships between feed energy supply and energy requirements for particular production situations. Feed rationing systems combine these feed evaluations with estimates of nutrient requirements. Such systems use empirical or, increasingly, mechanistic relationships which relate energy (or other nutritional parameters) based animal feeding trials to laboratory measurements of feed quality.

One of the earliest feed rationing system was the Total Digestible Nutrients (TDN) system. This is still in use in some parts of the world today! TDN is based on the simple empirical relationship:

TDN = digestible organic matter + 2.25 x digestible ether extract.

This system is static and does not take into account energy lost as methane and in the urine which tend to be relatively high with roughages. It has been widely used, particularly in the USA. However, more complex systems based on ME or NE have become increasingly widely used because of their greater accuracy over a wider range of conditions. These have been developed as techniques for measuring energy exchanges (calorimetry using respiration chambers) have become widely used. To quote ∅rskov and Ryle (1990) "...many respiration chambers were established in many parts of the world and, with them, almost as many feed evaluation system.". The Metabolisable Energy system used in the United Kingdom and elsewhere may be implemented with direct measurements of feed ME values. However, this is impractical even in temperate systems where relatively few feeds are used and relatively little variation in feed quality is encountered. More commonly, predicted values derived from equations which relate contents of digestible components (crude protein, fibre, lipids, nitrogen-free extract) to measured ME values may be used (see Van der Honing and Steg, 1990). A range of equations linking ME or NE to chemical compositions and *in vivo* or *in vitro* digestibility measurements have been developed for various uses (reviewed by Van der Honing and Steg, 1990; Thomas, 1990; AFRC, 1993). Digestibility data from *in vivo* experiments exist for many temperate feeds, but estimates of *in vivo* digestibility based *on in* *vitro* digestibility studies may be used where *in vivo* data are not available or where literature data may not adequately represent the particular feed samples being evaluated (i.e. in the case of most tropical feeds). The Tilley and Terry (1963) and enzymic procedures are commonly used to measure digestibility *in vitro*. Near infra-red reflectance methods using reference samples of known *in vivo* digestibility have become increasingly popular in the UK feeds industry in recent years. It is unlikely that these will ever be effectively or widely applied to the huge range of feeds found in the tropics.

Recently, attempts have been made to assess the role energy supplies to the rumen microbial population separately from that to the animal. The fermentable metabolisable energy (FME) is a measure of the ME available to rumen microbes, which is defined as the total ME less the ME in fat and fermentation acids which microbes are unable to utilise (but which can be utilised by the ruminant). FME supply determines the extent of microbial biomass production in the rumen, assuming other nutrients are not limiting. It is particularly important in establishing the interdependence of protein and energy supplies in ruminants and is, therefore, considered in more detail below.

Several texts are available giving a more complete description of energy evaluation and utilisation systems, for example Van der Honing and Steg (1990), ∅rskov and Ryle (1990), AFRC (1993).

Protein

In common with other farm livestock, ruminants require protein for maintenance, production and growth. Their rationing is complicated, however, by the fact that the rumen microbes that act as digestive intermediaries in this process have distinct requirements for nitrogen. Therefore, to be effective, modern rationing systems for protein generally consider the protein requirements of the animal and the microbial population separately.

Crude protein (CP) content, conventionally taken as nitrogen x 6.25, is used as the simplest, quantitative indicator of protein in feeds. Rumen microbes degrade this protein to yield nitrogen in the form of ammonia but then re-sythesise microbial protein to varying extents using the energy supplied by rumen cellulolytic bacteria. Some protein may also be degraded to yield amino acids and peptides that may be used directly by rumen microbes. Thus responses to the direct ingestion of non-protein nitrogen (e.g. urea) usually differs from that to iso-nitrogenous quantities of protein nitrogen.

Animal feeding trials have been used to determine the apparent digestibility of protein (DCP) in a wide range of temperate feeds and the earlier UK-DCP rationing system relied on book values to formulate rations that met protein requirement. However even for roughages in temperate countries the degree of variability and relatively low CP contents made this approach questionable in spite of the availability of empirical prediction equations such as the following, used for grasses, hays and silages:

$$DCP\ (g\ kg^{-1}\ DM) = CP\ (g\ kg^{-1}\ DM) \times 0.9115 - 36.7$$

Under tropical conditions where such variability is routinely many times that encountered in temperate feeding systems such an approach is unlikely ever to be widely useful.

More recently rationing systems have been developed that use estimates protein transactions that distinguish between protein degraded in the rumen that ultimately may become available to the ruminant as microbial protein (rumen degradable protein, RDP) and protein that is preserve for possible post-ruminal digestion (undegradable dietary protein, UDP). Using the dynamic model of ∅rskov and MacDonald (1979) rumen degradable protein can be partitioned its quickly degradable protein (QDP) and slowly degradable protein (SDP) fractions. When degradation and passage rates for SDP are known, this dynamic model may be used to assess the proportion of ingested SDP that escapes degradation in the rumen to be, potentially, digested post-ruminally.

The Metabolisable Protein (MP) system, currently used in the United Kingdom, uses this dynamic model to estimate the amount of rumen degradable protein captured by rumen microbes. This is checked against the energy available in the rumen (FME) and duodenal protein supply that may be limited by energy or protein supply in the rumen is predicted (AFRC, 1992; 1993). *In vivo* measurement of protein degradation requires animals with duodenal *cannulae*. It is time consuming and of questionable accuracy. Therefore, the nylon bag (*in sacco*) technique described by ∅rskov and McDonald (1979), although not without faults, has become widely used technique for providing working estimates of protein degradability (van Straalen and Tamminga, 1990). Kandylis and Nikokyris (1991) have produced an extensive list of published *in sacco* protein degradabilities for mainly temperate feeds. The mobile nylon bag technique is used to estimate intestinal digestion of protein due to difficulties in making in vivo measurements (for example, see Frydrych, 1992). A major assumption of the nylon bag techniques is that feed disappearing from the bag is degraded. The Acid detergent insoluble nitrogen (ADIN) assay is used as an indicator of the protein which is not degraded in either the rumen or lower gut (AFRC, 1993). While these techniques are the most useful currently available, they have their limitations both in terms of ease of use and accuracy (Webster, 1992).

Like the MP system, the French protein evaluation system (Vérité and Peyraud, 1989) seeks to predict the protein supply in the duodenum based on the partitioning of microbial and other nitrogen. It assigns two protein values to each feed, a lower value that relates to a feed used in isolation (PDIN) and a higher one that indicates the potential value when the feed is associated with a suitable complimentary feed (PDIE). These values are the sum of the feed protein undegraded in the rumen and either PDIN or PDIE. When calculating the protein supply to the animal (PDI) the PDIN and PDIE values of all the ingredients of the diet are summed separately (PDIN and PDIE values must not be added together) and the actual PDI value is taken as the lower of the two values. This system is not based on a dynamic model but it has been used widely and even adapted with some degree of success for use in the tropics (e.g. Pozy and Dehareng, 1996).

Animal Requirements

Most feed evaluation / rationing systems for ruminants consider supplies of and requirements for energy and protein separately, although more recent systems seek to encompass their interdependence in determining levels of performance. In rationing systems for the temperate zone, these are generally described in terms of nutrient requirements for a specified level of production (Tamminga, 1995). Thus, the system can be considered as being driven by outputs of products rather than inputs of feed. In many situations in the tropics, a rationing system is required to predict production responses to changes in inputs. It is possible to achieve this by algebraic manipulation of the mathematical relationships that make up requirement-based (output-driven) rationing systems. However, it must be accepted that relationships derived in this way may no longer be optimal (Elston and Glaseby, 1991). The system uses the nutritive value of the feed when fed as part of a balanced diet and nutritive values of feeds in a diet are assumed to be additive, thereby facilitating the use of linear programming approaches to least cost rationing. In temperate feeding systems energy is normally the first limiting factor in the supply of nutrients (AFRC, 1993).

Project Purpose

The project was designed to contribute to output 1.4 of the Livestock Production Programme's High Potential Production System. Its purpose may therefore be stated as:

> *Improved strategies for animal husbandry and nutrition in the intensive livestock production system and in crop/livestock systems in high potential and peri-urban areas* developed *and* promoted.

Research Activities

Implementing the Project

During its lifetime, this project experienced a number of quite major difficulties:

- Staff changes in a collaborating institute prevented the delivery of inputs relating to the core modelling activities from this source. It had originally been intended that this model should underpin the operation of the practical system;
- A re-assessment of data availability for the effective operation of the proposed system in the field led to the conclusion that this original approach would not result in the development of a viable rationing system;
- Re-aligning the project's activities to account for these first two problems, and the development of a new approach, necessarily put a considerable strain on the resources, in particular time, available;
- This was exacerbated by an over-commitment of the principal investigator's time and associated problems in securing inputs from other sources to alleviate this difficulty.

In spite of these problems, R6282 has now delivered its key outputs in the form of a computer software package entitled "DRASTIC – A Dairy Rationing System for the Tropics". In addition, the project has initiated the wider dissemination of the new system through a series of workshops in Bolivia and Tanzania and the wider distribution of publicity material to possible users.

The Construction of DRASTIC

What is DRASTIC?

The DRASTIC computer software packages a new approach to rationing dairy cattle in the tropics.

A major problem of rationing cows under these conditions is the lack of information on the nutritional quality of available feeds - particularly in the basal ration. This is compounded by a high degree of variation in feed quality that makes routine chemical analysis or reliance on "book values" for composition of little practical use.

In order to address these difficulties, DRASTIC formulations makes positive use of the variability observed in tropical feeds. This is achieved by using a database that uses working estimates of the range in key quantitative parameters rather than trying to assess absolute values. DRASTIC's core biological simulation model is, essentially an adaptation of the UK, Metabolisable Protein System (AFRC, 1993). However, the system is novel in that simple indicators of feed quality *that may be applied by farmers* are used to prime an artificial intelligence algorithm. This generates data from the ranges in the database to run the biological simulation of protein and energy nutrition that predicts the outcome, in terms of milk production achieved, of using a particular mix of feeds.

Who is DRASTIC Designed For?

Most dairy producers in the tropics have no direct access to computer technology.

DRASTIC has been designed for operation by those responsible for supporting the dairy sector. This might include extension staff or technical staff in dairy co-operatives. It is assumed that these users will have regular contact with their client farmers and will be able to use that contact to gather the data that are required to run the system. The other key feature of DRASTIC is the way in which it has been designed to be easy for these target users, who may have had limited training in information technology, to operate.

Testing DRASTIC

DRASTIC has been tested in a number of situations, both formally and informally. This section of the report briefly describes some of the findings of this testing.

Formal Testing

As part of the project's activities, a detailed collection of feed use and performance data was established in Bolivia in collaboration with the DfID bilateral-funded "Dairy Cattle Nutrition Project" in Santa Cruz. This aimed to produce a data-set that could be used to define some of the features required of the new dairy rationing system and to validate it. This data collection has been supplemented with other similar data sets collected by other RNRKS projects (R5690 in Nepal; R6359 in Tanzania; R6775 in Kenya) in which the principal investigator has been involved. However, the changes in emphasis required by the project (see page 12) have limited the use of these data sets in testing DRASTIC. In particular, the switch to an approach based on the use of largely qualitative input data that was made when the Dijkstra *et al*. (1996) core model was abandoned for the construction of DRASTIC has compromised the utility of these more quantitative data sets. Specifically, it is stressed that the data collected in these studies were not entirely adequate for testing of DRASTIC for the following reasons:

- No data describing the quality indicators used by DRASTIC are available;
- The resolution of the data-sets (fortnightly visits lasting one day) is not ideal as they do not allow for short-term fluctuations in supplementation to be identified;
- With, more or less, the exception of the Tanzania data-set, the impacts of associations with calves are not adequately covered;
- Indications of cow quality were only available for the Tanzania data-set;
- Forage *consumption* has been reliably estimated in the Nepal data-set only.

Nevertheless, as stated earlier, DRASTIC was designed for use in situations where input data are patchy and unreliable so need to use these inadequate data sets for testing should, perhaps, be regarded as a challenge rather than a limitation.

Whilst none of the available data-sets were judged to be entirely adequate for testing DRASTIC it was decided that, on balance, data collected by project R6359 ("*The Development of Feeding Strategies to Improve Reproductive Performance and Milk Yields of Cows in High Potential, Mixed Farming Systems*") on smallholder dairy farms in Tanga

Region, Tanzania would be most appropriate for an attempt to test DRASTIC. Accordingly 604 observations of forage and supplement use and associated levels of milk production from 70 cows from 49 farms were collated. These records were used individually to furnish the input data for a series of DRASTIC predictions of milk yields. In order to use the data in this way, it was necessary to make the following assumptions:

- Qualitative indicators were estimated from seasonal effects;
- Forage intakes were estimated from the lower of the forage offer rate and the predicted dry matter intake of the animal;
- Details of supplement compositions were estimated from qualitative information collected for each farm.

The outcomes of these individual predictions are presented in the graphs presented in Appendix 1.

Figure 2: *The distribution of individual errors for 604 DRASTIC predictions of milk production from smallholder dairy cattle in Tanga Region, Tanzania.*

Figure 2 summarises the distribution of the errors associated with the individual predictions made with DRASTIC for the Tanzania data. The more-or-less balanced bell shape of this curve suggests that, for this data-set at least, there is no evidence of any systematic tendency of DRASTIC to under- or over-predict milk yields. However, there were clearly a number of cases where DRASTIC predictions were substantially different (more than ±30%) from the milk production data recorded. There are a number of possible explanations for this:

- Errors in data recording. In some cases infeasibly large forage and supplement offer rates were apparent in the data-set (cows fed 20 kg of supplement do not produce 2 litres of milk / day) or implausible levels of variation in recorded milk production were observed;

- Inappropriate assumptions made to run the predictions. Variations in the quality of forage from different sources may be as great as that over seasons so basing the estimates on seasonal variability alone may have introduced considerable error into individual predictions;
- Systematic under- or over-prediction. Whilst there was no evidence of this for the data-set as a whole, it is not possible to rule out the possibility that, under certain circumstances, DRASTIC may under- or over-predict milk yields leading to more serious errors than normal. These are more likely to come to light through future interactions with the growing network of DRASTIC users.

Notwithstanding the limitations of the test data-set, the level of accuracy achieved with this testing is very encouraging for the wider uptake of DRASTIC. Indeed, with no direct assessment of the qualitative indicators used by DRASTIC, a mean prediction error of ±14.8% is considerably better than might be expected. The standard error of the DRASTIC milk yield predictions presented here was 1.1 litres / day which suggests, that in almost 95% of cases, an error of less than 1 litre / day may be expected when DRASTIC is used.

Table 1: *Observed and predicted yields for dairy farms in Santa Cruz, Bolivia.*

Farmer	**Actual milk yield** (litres / day)	**Yield predicted by DRASTIC** (litres / day)
Eduardo	20	19.1
Fidel	15	15.4
Fito	8	8.2
Juan	12	9.9
Miguel	8	7.9
Oscar	8	7.9
Rosendo	15	14.5
Toto	8	7.4
Yapacani tecnico	8	7.3

Informal Testing

Informal testing of the DRASTIC software was undertaken with participants in the Bolivia Workshops during both the seminars and the farm visits. Participants were asked, individually, to supply input data (including current actual milk yields and ration compositions) for running the programme. The actual milk yields achieved were then compared with the predictions made by DRASTIC (Table 1). Again, these results were (considerably) more accurate than anticipated, with an average prediction error of around 5%. This would suggest that, with complete input data, very high levels of accuracy should be possible with DRASTIC and are extremely encouraging for wider dissemination and development of this approach to dairy rationing.

One of the farmers (Juan) appears to have produced a combination of feeds that has fooled DRASTIC into a prediction error of around 21 *per cent*. This was discussed at some length (considerably greater length than more successful predictions) and the conclusion was that the quality indicators available for the fresh brewer's grains used by Juan were not entirely appropriate. This has been addressed in the release version of DRASTIC (Version 1.0) that has been produced since the Bolivia workshops were held.

Further Testing

Distribution of the evaluation version of the software (see page 29) has stimulated a number of organisations to invest their own resources in the uptake and testing of DRASTIC at both a formal and an informal level. These include:

- Universidad Tecnical del Beni, Bolivia.
- Smallholder Dairy Project, Kenya;
- National Dairy Cattle and Poultry Research Programme, Kenya;
- Caldas University, Colombia;
- University of the Philippines at Los Baños.

DRASTIC is also likely to be used in *ex ante* intervention testing in a new proposal for LPP research funding submitted by D. Romney (Natural Resources Institute) and M. Herrero (University of Edinburgh).

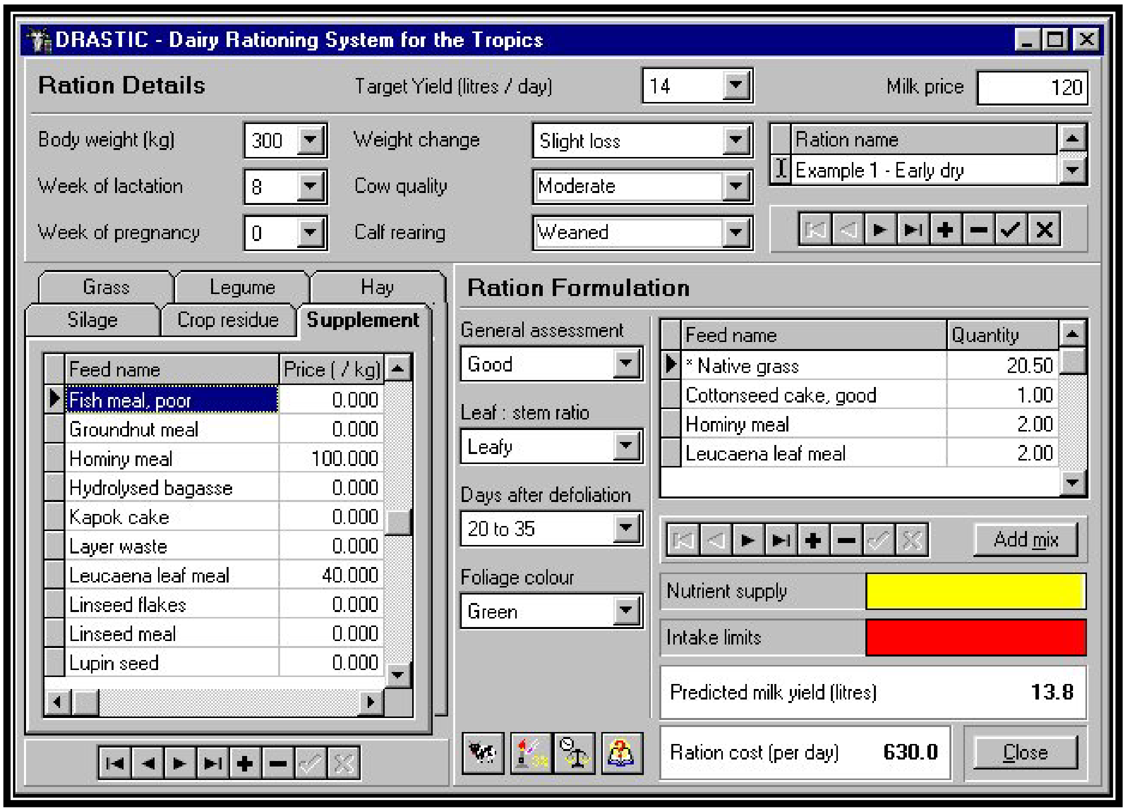
Outputs

DRASTIC – A Dairy Rationing System for the Tropics

The DRASTIC software is now available in both English and Spanish language versions.

A Worked Example of a DRASTIC Ration Formulation

The following worked example can be accessed in the database supplied with DRASTIC. The screen shots illustrate the use of DRASTIC but, if a copy of the software is available, you might like to work through it. Other possible options for the situation described may be explored independently.



The animal data are as follows:

Variable	*Value*
Body weight	300
Week of lactation	8
Week of pregnancy	0
Weight change	Slight loss
Cow quality	Moderate

Calf rearing	Weaned

The feed prices used, entered in arbitrary units, are as follows.

Feed	*Price*	*Feed*	*Price*
Native grass	10	Leucaena leaf meal	40
		Cottonseed cake, good	145
		Hominy meal	100

NOTE: If you are running a copy of DRASTIC in which feed prices have been modified, you will not get the answers presented here.

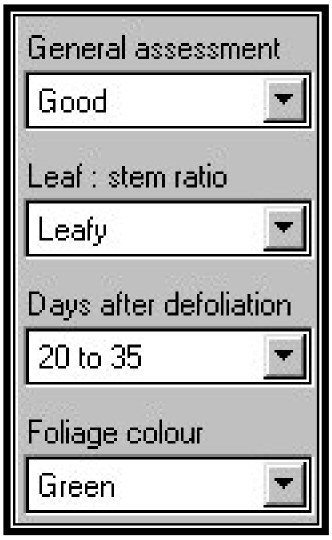
Responding to Seasonal Changes in Pasture or Forage Quality

Run DRASTIC and go to the ration named “Example 1 – Early Dry”.

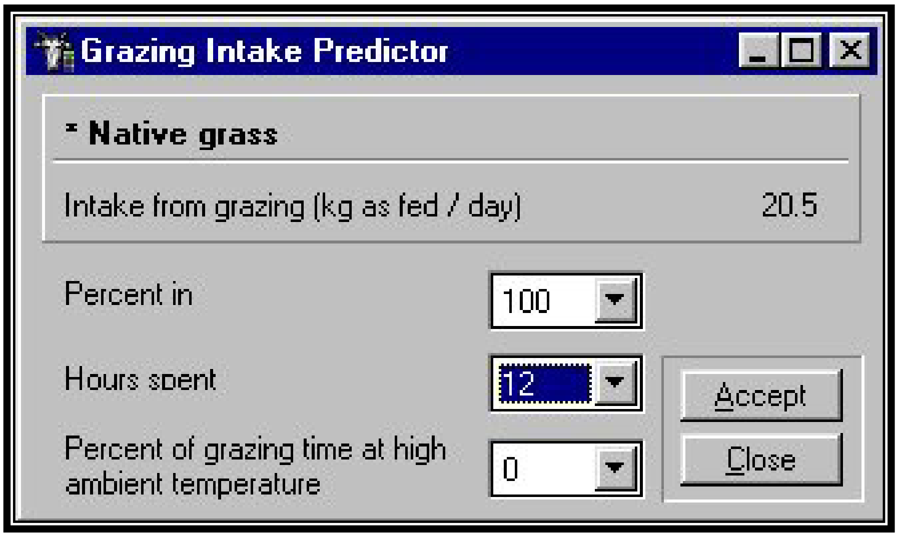
This example, in two parts, explores some of the consequences of a seasonal change in pasture quality.

Part 1

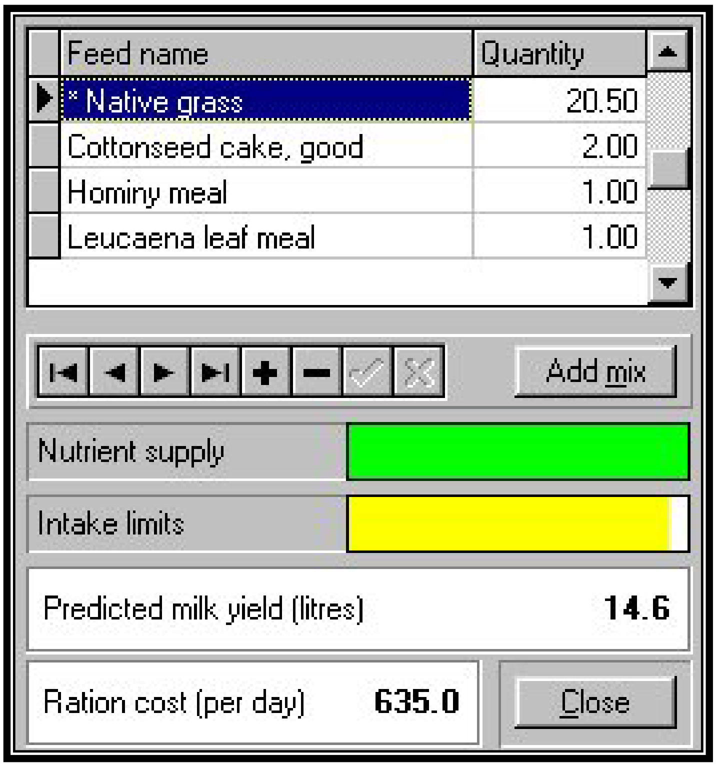
In the first part of this example, the cow grazes relatively lush, native grass shortly after the end of a rainy season. Accordingly, the pasture quality indicators have been assessed as:



The grazing intake predictor, set for 12 hours grazing of 100% native pasture with no influence of high ambient temperature, has been used to predict an intake of 20.5 kg as fed / day for the grass.



In order to meet a target yield of 14 litres / day, the following supplementation regime has been formulated from available feeds:

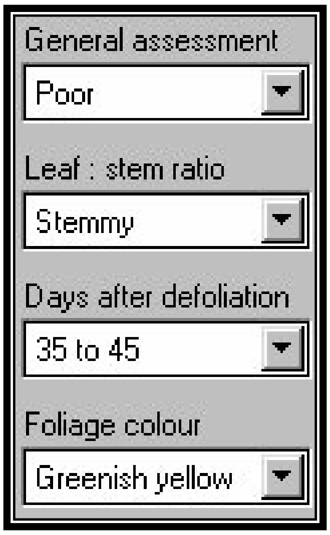


DRASTIC predicts a milk yield of 14.6 litres per day for this early dry season feeding strategy. This meets the target yield and is within the intake limits of the animal. The ration costs 635 / day and 43.4 / litre of milk and generates a margin over feed costs of 1122.1.

Part 2

Now go to the ration named “Example 1 – Late Dry” which represents the same animal grazing the same native pasture three months into the dry season.

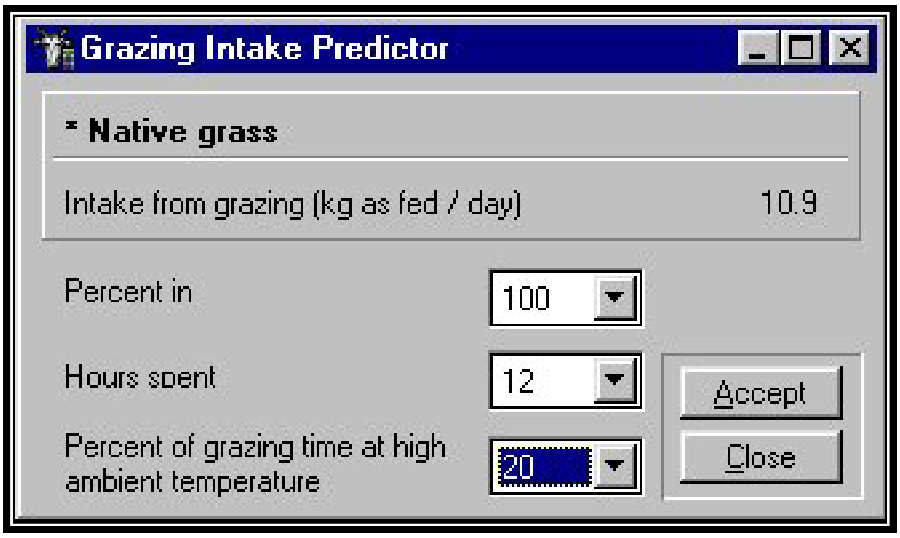
As the dry season progresses, the quality of the native grass pasture may be expected to decline. This is represented by the following, changed values for the quality indicators:



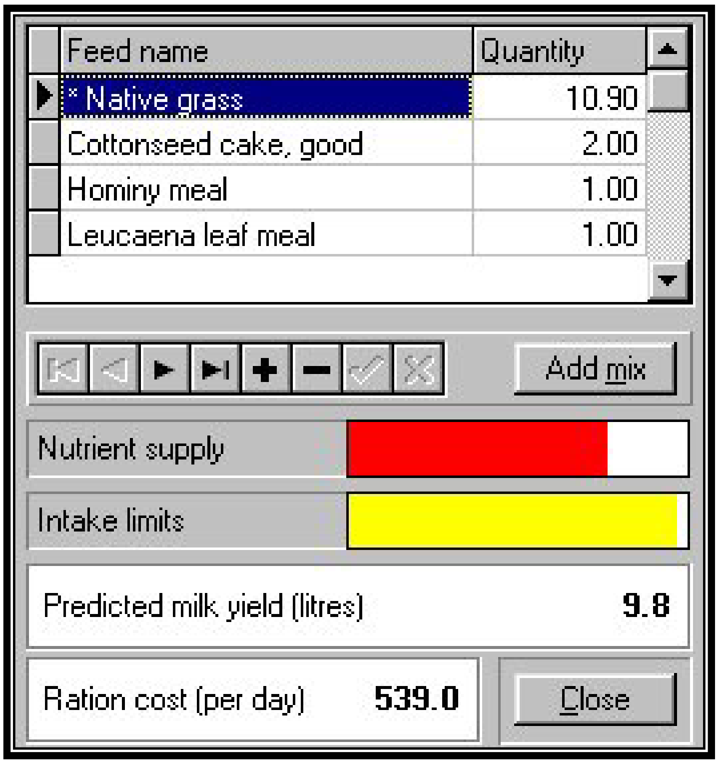
regrowth is less rapid so the interval between successive grazings is extended.

The following changes to the animal variables must also be made:

Running the grazing intake predictor again with these revised values, set for 12 hours grazing of 100% native pasture of which 20% takes place during a hot part of the day, suggests an intake at pasture of 10.9 kg / day. This is substantially less (although higher in dry matter) than the prediction for the first part of this example.



Using the same supplement regime, the predicted milk yield is reduced to only 9.8 litres per day and, assuming that supplement costs have not changed, the ration costs while reduced to 539 / day are increased because of the lower yields, by around 20%, to 55.3 / litre of milk. Margin over feed costs is almost halved to 631.3.

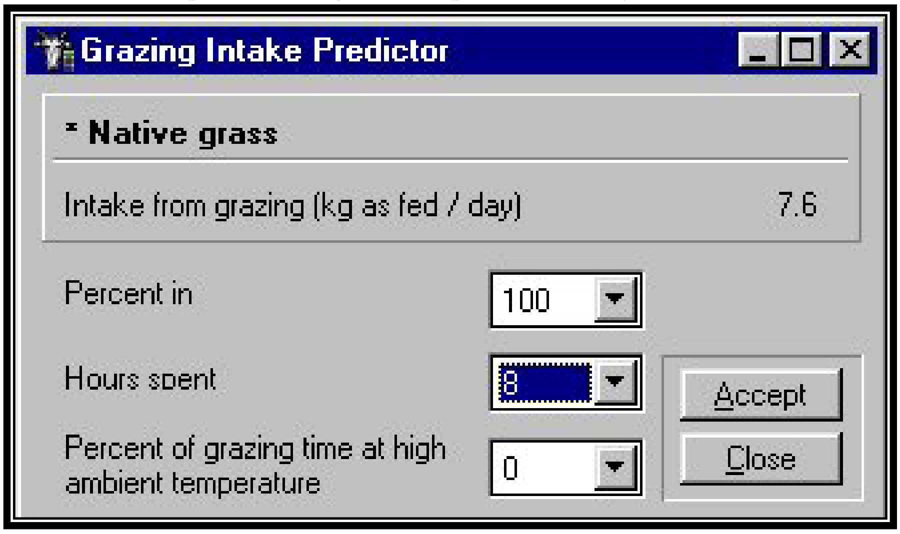


The current ration is close to the intake limits of the animal. Therefore, increasing the level of supplementation to compensate for the reduction in grass quality does not appear to be a viable option.

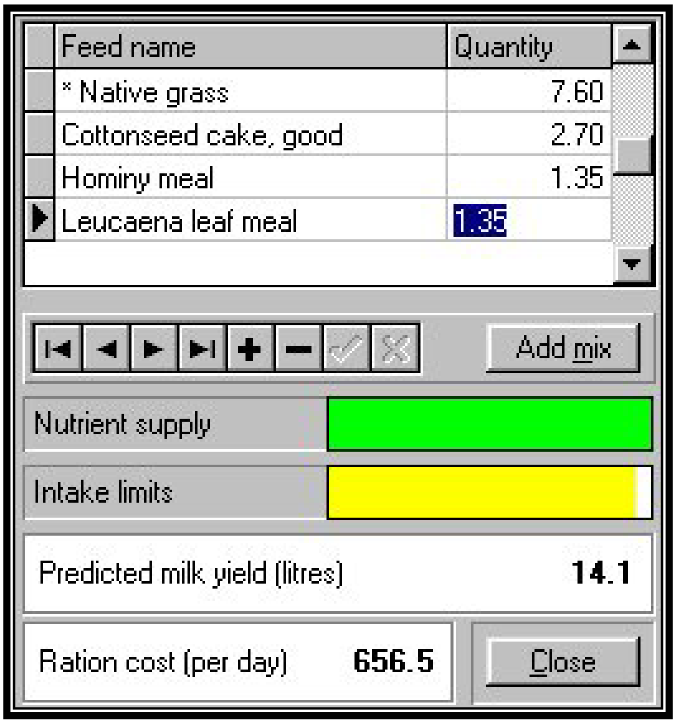
However, if milk prices are high (as they often are later in dry seasons), it may actually be worth the farmer's while to restrict grazing further to allow a higher level of concentrate feeding.

You can examine the impact of this option using "Example 1 – Late Dry":

- Run the grazing intake predictor, set for 8 hours grazing of 100% native pasture of which 0% takes place during the hot part of the day.



- Accept the prediction of 7.6 kg / day for the intake of native grass.
- Increase the levels of supplementation to:



Daily feed costs are increased considerably to 656.5. However, the increase in yield (to 14.1 litres / day) stimulated by the switch from grazing to concentrate has actually reduced the cost per litre to 46.6. These are, in fact, not far above the costs associated with the ration used in the early dry season and the margin over feed costs is largely restored to 1033.5. According to the DRASTIC prediction, this revised ration does not exceed the intake limits of the animal and the concentrate : forage ratio will not high enough to cause digestive upsets.

Contribution of Outputs

In the past there has been much criticism of the relevance of modelling approaches to the solution of farmers' problems. The development of DRASTIC has demonstrated that, provided that the use of models is focused and a bottom-up approach is adopted, there is, potentially, a very large contribution to be made. Essentially DRASTIC is a dynamic biological model that has been packaged for use by extension services with limited technical knowledge in situations where reliable quantitative data are difficult to access.

Although basically a feed rationing tool, DRASTIC can, because of its interactive nature, be used, at several levels, to plan feeding strategies in response to many of the real management questions that arise from the dynamic nature of dairy production in the Tropics. These might include:

- Responding to seasonal changes in pasture or forage availability and quality;
- Assessment of the impacts of changes in supplement availability;
- Assessment of the potential benefits of introducing new supplements into a region;
- Assessment of changes in cost benefits of supplementation with changing milk prices;
- Identification of break points resulting from changes in supplement prices.

Proper dissemination of DRASTIC should result in this level of analysis becoming available to smallholder dairy producers and managers, even amongst poorer income groups for the first time.

Dissemination Activities

Dissemination Workshops in Bolivia

The Dairy Cattle Nutrition Project (DCNP) in Santa Cruz, Bolivia was funded by DFID from July 1994 to November 1997. Project R6282 was fortunate in being able to collaborate with the DCNP from May 1985 allowing the collection of data collection on milk yields and live weights of local dairy cattle following a visit by Dr Thorne to Bolivia.

The proposal that part of the eventual field evaluation trials of the rationing system should be held in Santa Cruz was posed to the milk producers participating in the data collection by Dr Thorne on his second visit to the DCNP in June 1996. In order to feed information back to collaborators, a series of workshops was included amongst the activities of project R6282. The two workshops in Bolivia that are described here were organised by E. Alderson during a preparatory visit undertaken in June, 1998.

Workshop Objectives

The Bolivian workshops were undertaken with the following objectives:

- To demonstrate the use of the DRASTIC software to collaborating dairy co-operative technical assistants, university staff and farmers in Santa Cruz and Trinidad, Bolivia.
- To provide copies of and documentation for the current, evaluation version of DRASTIC software to these collaborators for final assessment and feedback prior to the release of a full version of the software in mid-1999.

The workshops in Santa Cruz (24 – 25 November) and Trinidad (27 – 28 November) were judged to have been extremely successful by both participants and organisers alike. The former was attended by around 30 farmers and by technical staff from FEDEPLE. The latter attracted a total of 85 participants including farmers, students from the Universidad Technical del Beni (UTB) and technical staff from FEGABENI and ADEPLE (BENI). A clash with a pasture management workshop -held by another LPP funded project in Santa Cruz - did not appear to affect attendance although it would suggest a need for better co-ordination amongst projects.

Workshop Activities

Informal testing of the DRASTIC software was undertaken with participants during both the seminars and the farm visits. Participants were asked, individually, to supply input data (including current actual milk yields and ration compositions) for running the programme. The actual milk yields achieved were then compared with the predictions made by DRASTIC. These results were (considerably) more accurate than anticipated, with an average prediction error of around 5%, and are extremely encouraging for wider dissemination and development of this approach to dairy rationing.

Heavy rains led to the cancellation of farm visits scheduled for the Santa Cruz workshop. In Trinidad, participants were able to work with the DRASTIC software using field observations of the available feeds (pastures and supplements) for designated animals. Results from this process were also encouraging although a need to incorporate amongst animal effects for predictions used in this way was identified.

A number of matters arose from activities and discussions during the workshops:

- The utility of the DRASTIC software for generating interest amongst farmers in improved feeding strategies was particularly apparent in the Trinidad workshop. The interactive, visual format of the software clearly generated much more impact, and appeared to carry more weight, than verbal recommendations. One participating farmer, said by his friends to be "careful with his money" took immediate steps to implement the new feeding regimes developed using the software during a visit to his farm.
- The president of FEDEPLE (Sr. Javier Roque Suarez) is also President of the Bolivian National Milk Producers Association. Sr. Roque Suarez requested us to seek funding to allow similar workshops to be held in other milk producing areas of Bolivia (La Paz, Cochabamba, Tarija and Sucre) next year.
- FEDEPLE were keen to establish the use of DRASTIC in their member associations throughout the department of Santa Cruz. Dr Cadario has agreed to initiate this process.

Release of Software for Evaluation

The level of interest in the DRASTIC software from local workshop attendees was extremely high and stimulated enthusiastic and interactive participation. Numerous requests for copies of the software were received from participants and around 20 copies of the evaluation version were distributed during the workshops. Dr Cadario (FEDEPLE) and Dr Nagashiro (UTB) undertook to keep Dr Thorne informed of future demand for the software so that he can ensure that they are adequately provided with distribution discs and manuals.

Modifications to DRASTIC

Workshop participants suggested a number of modifications to the evaluation version of DRASTIC. Some of these have been included subsequently in the current DRASTIC Version 1.0:

- Allow a number of user specified options (e.g. allow priced to be set on a per kg **or** a per tonne basis);
- Include ambient temperature as a factor affecting predictions of intake at pasture;
- Include price information in ration summaries;
- Display more quantitative data during formulations (this is unlikely to be useful for most target users although a future "Pro" version of DRASTIC might be constructed to offer this facility);
- Prices need to be specified to more than two decimals where they are quoted on a per kg basis;
- More detailed nutritional information could be supplied on the ration summaries (again, this would probably be more appropriate for a professional version of the software);

- Information on ration costs per litre of milk would be useful as well as ration costs per cow per day;
- Some floating point errors generated by the operation of the core model were observed during testing;
- Some recalculation errors following the deletion of feeds from rations were also noted but this bug appears to have been fixed during the workshop.

Dr Nagashiro (UTB) suggested that more formalised on-farm testing of DRASTIC could be undertaken by some of his students as part of their honours projects. Dr Thorne agreed that some funds could be found to support this and the key issues to be addressed by this short work programme were identified.

Dissemination Workshops in Tanzania

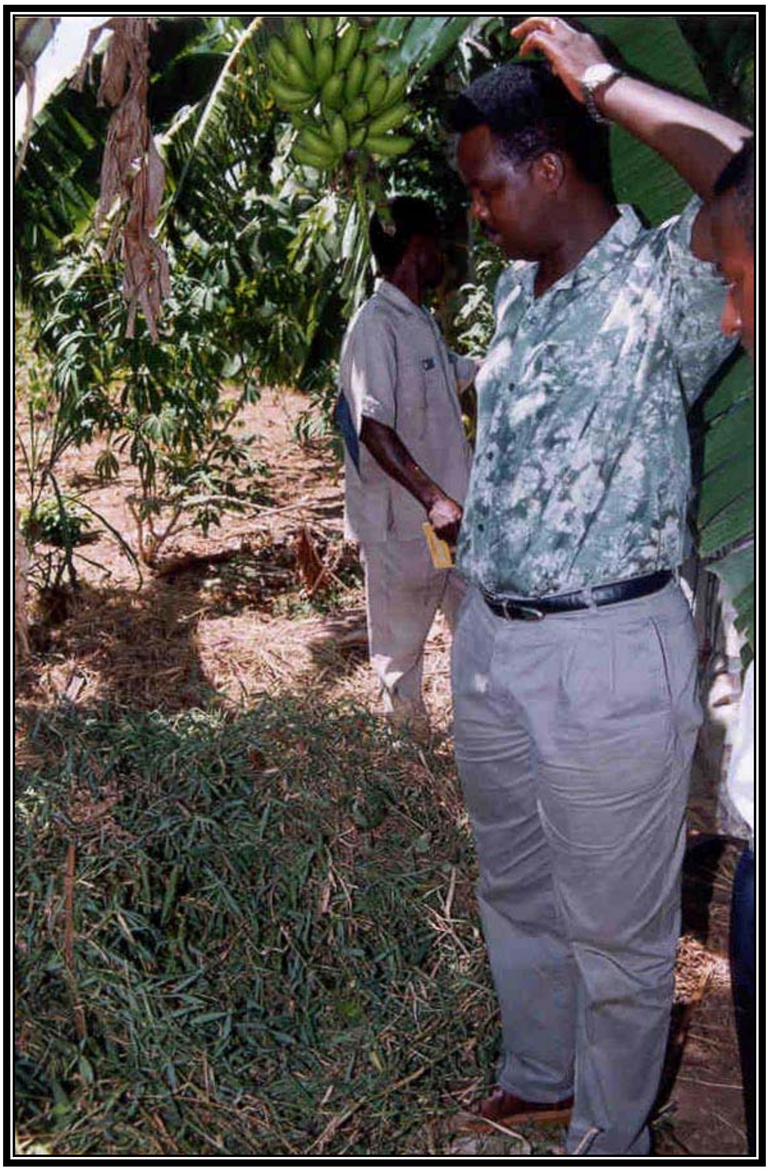
Plate 1: *A Small Group of Extensionists and Local and Foreign Experts Visits a Farmer in Tanga Region During a Workshop Field Trip.*

The two workshops in Tanga (6 and 8 January, 1999) both ran smoothly. Each included a morning discussion group on dairy rationing and an afternoon field trip. Participants (Annexe 1) included farmers, extensionists and technical and managerial staff from the Tanga Dairy Development Project and the Tanga Livestock Research Centre.

Key points arising out of the workshop sessions were:

- Under the conditions prevailing in Tanga region, the DRASTIC software offers a quick and easy way of assessing alternative feeding strategies. A number of specific modes of use were identified by particpants during the course of the workshop:
- Assessment of the impact of changing supplement availability;
- Assessment of the potential benefits of introducing new supplements into the region;
- Assessment of changes in cost benefits of supplementation with changing milk prices;
- Identification of break points resulting from changes in supplement prices.

Plate 2: *A Local Expert Makes a Visual Assessment of the Quality of Cut-and-carried Forage for use in a DRASTIC Prediction.*



The gathering of data to run the system and the presentation of DRASTIC's predictions back to the farmer were identified as areas requiring further consideration *for the level of extension input found in Tanga region.* Interestingly this was not an issue with other target institutions of the DRASTIC project in Bolivia. Participants suggested the following requirements:

On a day-to-day basis extensionists have experienced some difficulties in establishing farmers / livestock managers current management practices (there appear to be a variety of reasons for this). The reliability of this interaction would need to be improved;

A focus for examining the dairy rationing alternatives is needed. One suggestion was that farmer / extensionist study groups currently being established by TDDP would provide a suitable forum for this;

One farmer participant confirmed the need for the involvement of those managing the livestock in the development of these approaches and other participants agreed the principle.

Copies of the software were left with TDDP and TLRC staff for evaluation purposes.

Initiating the Wider Dissemination of DRASTIC

Wider dissemination of DRASTIC was initiated in January 1999 using a limited mail shot of the publicity leaflet shown in Annexe 2. In the first instance 50 individuals were targeted, mainly in the applied research community. It is estimated that around 30 copies of the evaluation version of the software have been disseminated as a result of the mailshot. This includes a number of recipients who were not originally targeted but who have made a request as a result of recommendations from other DRASTIC recipients.

List of Dissemination Outputs

THORNE, P.J., SUBBA, D.B., WALKER, D.H., THAPA, B., WOOD, C.D. and SINCLAIR, F.L. (1999) The basis of indigenous knowledge of tree fodder quality and its implications for the use of tree fodder in developing countries. *Animal Feed Science and Technology*, (in press). [Science] (A).

THORNE, P.J. (1999) Developing integrated models for application in crop-livestock systems. pp 105 – 121. In: Proceedings of a Workshop on Ecoregional Research at ILRI. Addis Ababa, 5 – 8 October, 1998. (Eds.) P.K. Thornton and A.N. Odero. International Livestock Research Institute, Addis Ababa, Ethiopia. [Science] (A).

THORNE, P.J. (1999) DRASTIC. *A Dairy Rationing System for the Tropics. Version 1.0 for Windows 3.1*. Chatham, United Kingdom. Natural Resources Institute. 47pp. [Field] (G)

Thorne, P.J. (1999) DRASTIC. *Un Sistema de Racionamiento para Vacas Lecheras Tropicales. Version 1.0 para Windows 3.1*. Natural Resources Institute, Chatham, United Kingdom. 47pp. [Field] (G)

THORNE, P.J. (1999) DRASTIC – A Dairy Rationing System for the Tropics. [2 day Training and Dissemination Workshop for 87 Extension staff and Farmers]. English. TDDP, Tanga, Tanzania. 6, 8 January, 1999. [Field] (B)

THORNE, P.J. and HERRERO, M. (1998) The role of livestock in natural resources management. pp 87 – 94. In: Food, Lands and Livelihoods. Proceedings of an International

Conference held at the KARI Conference Centre, Nairobi, Kenya, 27 - 30 January, 1998. *BSAS Occasional Publication* no. **21**. British Society of Animal Science, Edinburgh, UK. [Science] (A)

THORNE, P.J. (1998) *DRASTIC-Un Sistema de Racionamiento para Vacas Lecheras Tropicales.Version de Evaluacion para Windows 3.1*. Chatham, UK, Natural Resources Institute. 40pp. [Field] (G)

THORNE, P.J. (1999) DRASTIC. *A Dairy Rationing System for the Tropics. Evaluation Version for Windows 3.1*. Chatham, United Kingdom. Natural Resources Institute. 47pp. [Field] (G)

THORNE, P.J. and ALDERSON, E. (1998) DRASTIC – A Dairy Rationing System for the Tropics. [2 day Training and Dissemination Workshop for 40 Extension staff and Farmers]. Spanish. AGANORTE, Montero, Bolivia. 24 – 25 November, 1998. [Field] (B)

THORNE, P.J. and ALDERSON, E. (1998) DRASTIC – A Dairy Rationing System for the Tropics. [2 day Training and Dissemination Workshop for 90 Extension staff, Farmers and Students]. Spanish. ADEPLE – Beni, Trinidad, Bolivia. 27 – 28 November, 1998. [Field] (B)

THORNE, P.J. (1998) Factsheet. English. 100 copies pp 2. [Science, Field] (D)

THORNE, P.J., SINCLAIR, F.L. and WALKER, D.H. (1997) Using local knowledge of the feeding value of tree fodder to predict outcomes of different supplementation strategies. *Agroforestry Forum*, **8 (2)**: 45 - 49. [Science] (A)

THORNE, P.J. (1997) *Summary of Cattle Performance on Dairy Farms in the Santa Cruz Area, Bolivia*. Unpublished NRI Report. NRI, Chatham, UK 145 pp. [Field] (C)

DIJKSTRA, J., FRANCE, J., NEAL, H.D. St. C., ASSIS, A.G., O.F.AROEIRA, J.M. and CAMPOS, (1996) Simulation of digestion in cattle fed sugarcane: model development. *Journal of Agricultural Science (Cambridge)*, **127**: 231 - 246. [Science] (A)

DIJKSTRSA, J., FRANCE, J., ASSIS, A.G., NEAL, H.D. St. C., CAMPOS, O.F., and AROEIRA, J.M. (1996) Simulation of digestion in cattle fed sugarcane: prediction of nutrient supply for milk production with locally available supplements. *Journal of Agricultural Science (Cambridge)*, **127**: 247 - 260. [Science] (A)

Distribution of DRASTIC

Versions of DRASTIC have been produced in both English and Spanish. The software is available free of charge and may be obtained from:
Dr Peter Thorne
NRMD, NRI
Central Avenue
Chatham Maritime
Kent, ME4 4TB
UNITED KINGDOM

Or as a zip file which may be downloaded from:

http://www.nri.org/NRMD/DRASTIC

Requirements for Further Research and Dissemination

Research

Drastic may be viewed as essentially an end-product in the research continuum as it is intended for direct use by extension services in support of their client farmers. Requirements for research follow-ups are therefore relatively limited

Key areas for future research that have been identified by the activities of this project include:

- The development of an extension methodology and training pack for promoting the use of DRASTIC in association with extension – farmer study groups in east Africa (Tanzania and possibly Kenya);
- Modifying DRASTIC so that it can be used to generate dynamic, pictorial extension guides to assist farmers directly in altering their feed management strategies in response to changing circumstances (Talking Pictures);
- The development of an integrated system for planning feeding strategies for draught animals (including draught cows).

At the time of writing, proposals for implementing research in these areas are in various stages of development.

Dissemination

Initial dissemination of the DRASTIC software (see page 29) has produced a number of encouraging contacts. However, There is clearly a need to continue the wider dissemination of DRASTIC on a global scale. It is intended that a proposal will be submitted for dissemination funding to cover:

- Identification and mail-shotting of a much broader base of potential users worldwide;
- Preparation and distribution of DRASTIC to respondents to this mail-shot;
- Maintenance of the software in response to comments received from users;
- Establishment and maintenance of an Internet web-site for distribution of software, updates and relevant information.

Proposals for wider dissemination through the medium of workshops similar to those held in Bolivia and Tanzania are being developed for:

- Other milk producing areas of Boliva;
- India.

A key issue for the future dissemination of DRASTIC and indeed any RNRKS outputs is the degree of commitment of the bilateral programmes within DfID to these. Initial contacts with DfID suggest that there are no mechanisms in place to encourage the wider dissemination of

RNRKS outputs in this way. A presentation of DRASTIC to include a discussion of the implementation of uptake pathways is proposed for DfID headquarters later in the year.

Acknowledgements

The contribution of Liz Alderson to the project - as a DfID technical co-operation officer in Santa Cruz managing the collection of on-farm data, translating the interface and manuals for the Spanish language version of DRASTIC and planning and supporting the dissemination workshops in Bolivia - has been indispensable and very much appreciated by the author.

In relation to the dissemination workshops, the author gratefully acknowledges the considerable assistance of staff from FEDEPLE, Santa Cruz, ADEPLE, Beni, the Universidad Tecnical del Beni, Tanga Dairy Development Project and Tanga Livestock Research Centre. In particular, Fernando Cadario of FEDEPLE, Carlos Nagashiro of UTB, Innocent Rutamu of TDDP and B.S.J. Msangi of TLRC contributed much, in both organisational skills and enthusiasm, to the success of these workshops.

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Annexe 1: Participants In Dissemination Workshops Held in Tanga, Tanzania

6 January, 1999

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1.	MOSHY F. W.	TANGA
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10.	MAVINDI C.	TANGA
11.	A. V. MBWANA	LUSHOTO
12.	M. R. MASANJA	MARAMBA
13.	MOSHA O. F.	TANGA
14.	ULEDI ECPE	AMANI
15.	B.S.J. MSANGI	LRC
16.	MBWAMBO T.N.	TANGA
17.	FRED L. SIMON	BUHURI
18.	P.Y. KAVANA	LRC
19.	E.L. MINJA	“
20.	MBESSERE LUKMAY	TANGA
21.	JOHN J. MNYIKAS	BUHURI
22.	KIMDA A.S.J.	PANGANI
23.	KHALFAN S.	KOROGWE
24.	SHIRIMA EJM	LRC
25.	FRED R. LINGA	KOROGWE
26.	SHABANI SEFFU	AMANI
27.	INNOCENT RUTAMU	TDDP

28.	LUUK SCHOONMAN	TDDP
29.	J. DIJKMAN	ILRI-ADDIS ABABA
30.	P. THORNE	NRI
31.	A. SPEEDY	FAO-ROME
31.	ROOPA RAJAH	FAO-ROME

8 January, 1999

	NAME	PLACE
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3.	SAS SHEMHINA	MUHEZA
4.	J.P. MRUTU	KOROGWE
5.	H.S. AYUBU	KOROGWE
6.	ABDALLAH NASSORO	TANGA
7.	JAMES S. MNGUMI	AMBONI
8.	SAMWEL MNGULU	LRC TANGA
9.	MBONDE DICKSON	TANGA
10.	ELIEZER MOSSES	LUSHOTO
11.	MAGHEMBE M.A.	LUSHOTO
12.	DAVID M. TUPA	TANGA
13.	JUMA ATHUMANI MAGOMA	AMANI
14.	MRS MAKANGE	TANGA
15.	TERRY E.K.	MARAMBA
16.	LYAKURWA R.E.	BUHURI
17.	MTALO M.	TANGA
18.	TEMBA P.A.	TANGA
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20.	A. MGHASE	TANGA
21.	LYIMO Z.C.	TANGA
22.	JOHN BEE	LRC - TANGA
23.	ARCHIE MNTAMBO	PANGANI
24.	SHOO J.E.	TDDP
25.	KILENGAWANA P.M.	KOROGWE
26.	ELIZABETH KWINGWA	MARAMBA
27.	NZUZU	PONGWE
28.	DAFFA A.Y.	PONGWE
29.	CHONGA R.N.	AI TANGA
30.	J.S. IBAYA	TANGA

31.	HUME S.N.E.	MUHEZA
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33.	RAMADHANI MOHAMED	TANGA
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35.	M.A. SINGANO	TANGA
36.	INNOCENT RUTAMU	TDDP
37.	A SPEEDY	FAO
38.	R. RAJAH	FAO
39.	P. THORNE	NRI
40.	J. DIJKMAN	ILRI

Annexe 2: Publicity flyer for DRASTIC.

Appendix 1: Summaries of Observed and Predicted Milk Yields for Study Farmers in Tanga Region, Tanzania.