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Approaches to understanding livestock feed requirements and identifying ways to improve fodder supply involving farmer and community initiatives.

Kiff, E[1]., Hendy, C.R.C[1]., Amatya, S. M[2]., Vickers, B[3]., Chhettri, R[3]., Kharel, R[2]. and Basukala, R[2].

[1] Natural Resources Institute, University of Greenwich, UK.
[2] Department of Forest Research and Survey, Ministry of forests and soil conservation, Kathmandu, Nepal
[3]Nepal Agroforestry Foundation, Kathmandu, Nepal

Abstract

Patterns of supply and demand for livestock feeds in the mid-hills of Nepal are increasingly subject to changing circumstances affecting land resources and access, farming and livestock production practices and objectives, and household circumstances. The availability of resources such as grazing and forest lands continues to decline as the extent and intensity of use of cropland increases and the introduction of improved management of remaining resources results in changed access. At the same time changes in livestock holdings towards fewer stall-fed animals, more productive breeds and more commercial orientation (for milk sales for example) continue to change demand for the amounts and quality of feeds. Changes in household structures, education and employment also alter factors of labour and cash availability for the collection or purchase of feeds. Clearly an improved understanding of the role of these various factors in the supply and demand for feeds will help to better inform the general approaches to improving feed supplies in the mid-hills zone.

There are two distinct aspects to building an understanding of fodder supply and deficit patterns in order to identify improved feeding strategies. One aspect is the description of current fodder management practices in terms of fodder availability and periods of shortage. The second aspect involves diagnosis of fodder nutrient deficits at household and individual livestock level, in order to be able to suggest changes to enhance production.
The first aspect, description of fodder availability and periods of shortage, has been well covered by previous research. Such studies have identified the different types of fodder available, broad quantities, quality and duration of their availability. However, analysis of this descriptive data in terms of key influencing factors determining differential household access to and use of the various resources, is less well covered by research to date.

Approaches to the description of current fodder management practices in terms of fodder availability and periods of shortage are considered, including using farmer recall, participative, and actual fodder collection measurement. The advantages and draw-backs to a range of approaches for the assessment of animal nutritional needs are also discussed, culminating in the presentation of a proposed improved diagnosis method.

The experience from support to farmers' practical efforts to address fodder deficits is considered in terms of key options and constraints to increasing feed supplies.

1. Introduction

Patterns of supply and demand for livestock feeds in the mid-hills of Nepal are increasingly subject to changing circumstances affecting land resources and access, farming practices, livestock production objectives, and household circumstances. The availability of resources such as grazing and forest lands to supply feeds continues to decline as the extent and intensity of use of cropland increases and the introduction of improved management of remaining resources results in changed access. At the same time changes in livestock holdings towards fewer stall-fed animals, more productive breeds and more commercial orientation (for milk sales for example) continue to change demand for the amounts and quality of feeds. Changes in household structures, education and employment also alter factors of labour and cash availability for the collection or purchase of feeds. Clearly an improved understanding of the role of these various factors in the supply and demand for feeds will help to improve the general approaches to improving feed supplies in the mid-hills zone.

While these general trends are occurring, fodder supply and demand at individual household level depends on the particular circumstances of households. Diagnosis of the requirements and options for individual households requires a simple approach which takes account both of the place of the household within the broad factors affecting supply and demand as well as the major specific household circumstances.

Ultimately, however, diagnosis of feed requirements cannot be done without a nutritional assessment of the current components and quality of diets, as well as of the options for improving diets. These options depend particularly on the basic feeds used in current diets as well as on the species, breed and production objectives for specific animals. The improvement of feed supplies is then a process of investigating the options and constraints on both the supply and demand sides of the equation. This paper discusses some of the alternative approaches both for research to better understand the factors affecting feed supply and demand and for improved diagnostic methods for use at the level of individual households.

2. Alternative approaches to improved understanding of patterns of feed supply and demand

In view of the changing circumstances affecting the supply and demand for feeds there is need for research to identify major determining factors and trends. As in other subject areas, field research approaches may be made at a range of intensities, details, durations and cost. Different approaches also have advantages and disadvantages in terms of the types and accuracy of information that may be gained. Approaches may be broadly distinguished as qualitative interview and discussion-based methods or quantitative measurement-based methods. In practice a combination of methods may be required to provide the most cost-effective approach.

All methods face certain key problems in the analysis of feed supplies and demand including the strong seasonality of supplies and the large number of variables and factors to be considered. The latter include the wide range of feed resources used, and the allocations of feeds to several different species of livestock, as well as important

household factors of land and tree holdings, livestock holdings, and labour availability or constraints. Understanding the seasonal variations in supply of feeds and the composition of diets is a critical factor in determining the options for improving the feeding of animals.

The following sections describe the components and relative merits of the different approaches.

2.1 Qualitative discussion-based methods

Much useful information may be obtained by discussion or interview-based methods. These may be conducted by structured discussions with groups of farmers and/or individual households. Various PRA methods are available to facilitate such discussions. Group discussions are useful to collect outline descriptions of factors such as the definition of seasons and patterns of fodder supply, access to communal off-farm land resources (grazing and forest), typical ranges of land and livestock holdings, cropping systems, the types and composition of feed resources available, livestock feeding systems for different species, and trends in changes in these factors affecting feed supply and demand. Following such group discussions, interviews with individual households are useful to collect information on individual circumstances and to attempt to quantify through recall the amounts of specific fodder supply and utilisation.

2.1.1 Single visit surveys

Single-visit surveys suffer the disadvantages that they can take a long time to cover all necessary issues and that information on aspects requiring quantification (such as seasonal amounts of fodders used) are of uncertain reliability. To avoid over-lengthy discussions, they may be conducted in more than one session, or with different groups of farmers (though in the latter case there may be problems relating the different sets of information). Single visit and PRA methods generally also suffer the disadvantage of requiring specialist and knowledgeable staff to conduct useful open-ended discussions (asking the right questions and understanding the answers). In addition, discussions require very good local language skills (or interpretation). The scale of these surveys may thus be limited.

2.1.2 Repeat visit surveys

Discussion or interview-based methods may alternatively be conducted in repeat visits through the relevant seasons. This provides the opportunity to collect more reliable quantitative information on current activities (such as amounts of fodder collected), still based on farmers' information but without reliance on long-term recall of seasonal-tied information. Repeat surveys also offer the possibility of using more structured interview methods for collection of specific seasonal information. Once designed, these surveys may be conducted by less-skilled staff in a more routine way (though they still benefit from sensible follow-up questioning and data checking). In this way the scale and coverage of surveys may be increased and the duration of individual interviews kept to a minimum to encourage continued participation by

farmers. Repeat visits may also allow cross-checking of information and correction of data in subsequent visits.

Repeat-visit surveys may be enhanced by the addition of some simple measurements of key variables. At least sample measurements and weighings of quantities in local measures (such as bhari) need to be conducted to provide conversion factors for quantities reported in local measures. However, the addition of too many routine measurements into interview methods may unnecessarily prolong data collection and risk continued participation by farmers.

Data on the allocation of fodders to livestock are particularly difficult to obtain by interview methods. Animals are fed at several times through the day and may be fed as part of a mixed-age group, making accurate recall of the daily total feed provision of each type of feed to an adult animal more difficult. Collection of data in this way is possible, however, as illustrated in single-visit and single-species studies such as that by Neopane *et al*. (1990) and Van der Grinten (1997), though with large variation. In households with several species of livestock and several types of fodder, interview methods of assessing diets offered to each species can be very time consuming.

An alternative simplified approach was adopted in the survey reported by Hendy *et al*., (2000 a and b). In this method, estimates were reported by farmers of the percentage of each collected fodder which was allocated to each species of livestock. These were later used to calculate the amounts of fodders allocated to each species. The method provided a reasonable description of the diets offered to different species of animals in different circumstances, sufficient to use as a base for preliminary interpretation of requirements to improve livestock feeding, though lacking detail for individual animals and in relation to production objectives.

2.2 Quantitative methods

While repeat-visit interview-based methods can provide a sufficient description of fodder collection and utilisation for many purposes, including the investigation of the major factors influencing fodder supply and demand, the accuracy of the measures reported in such surveys is essentially unknown. Simplifications in data collection to facilitate interviews inevitably result in reduced accuracy of measurement. For example, the reporting of fodder quantities in the relatively coarse local measures of bhari or doka, or the estimation of the specific composition of fodders (ie tree species in tree fodder) by approximate percentages, may lead to inaccuracies. In addition, some important variables may not be known by farmers, so cannot be recorded by interview. For example, farmers may not know what proportion of fodders offered to livestock for feed are actually consumed. The survey method cannot, therefore, provide information on feed intakes or the composition of consumed diets (though it may provide information on offered diets). Information on liveweight changes and productivity of animals is also difficult to obtain by recall. Thus the collection of accurate data requires more quantitative methods.

Depending on the objectives of study, quantitative methods may have the same requirements as interview methods to cover entire seasonal cycles and the full range of fodders collected and fed on holdings. Measurement of so many variables over long time periods is inevitably time-consuming and costly, and generally can be operated only on a small scale. Thus, collection of data from a wider range of locations or households may not be feasible, so the need to stratify and sample efficiently becomes more important. Preliminary interview-based methods are required generally to establish the ranges of critical factors to be studied (such as seasons, locations, land holdings and livestock holdings) and to determine sampling procedures.

Sampling intensity and input requirements for quantitative studies may differ for fodder collection and livestock feeding data. Whilst patterns of fodder collection vary seasonally, patterns of livestock feeding may vary also with production objectives. Thus, it may be important to sample feeding practices in lactating cattle and buffalo, or over working and non-working periods for oxen. The seasonality of these events may not match the broader seasonality of fodder collection or availability. Therefore, more careful sampling procedures may be required to cover such issues.

Practical issues of the collection of data are clearly more difficult and costly to manage in quantitative studies. Given the distribution of fodder collection and livestock feeding activities throughout the day, the methods usually require enumerators based in villages or households, necessitating logistical support. Large volumes of data are generated in such studies which require suitable systems for checking and assembly prior to analysis.

At the most intensive level, Thorne *et al*., (1994) described a year-long study in Eastern Nepal covering 10 households in six villages employing village-based enumerators collecting 24-hour records at two-weekly intervals. Data recorded included all feeds collected, offered and consumed (accounting for feeds not consumed as far as possible). In this case, the description of feed allocation in multi-species livestock holdings and of feeding patterns was a primary objective. So the posting of enumerators was necessary and, consequently, allowed the recording of information on fodder collection at the same intensity as on feed allocation.

Alternative approaches, with a wider study of fodder availability and collection rates (across more village and household circumstances), and more intensive study of feeding practices for selected livestock species and periods, might be designed with the objectives of improving specific feeding systems. Such studies might usefully be combined (and justified) with field trials of interventions to improve livestock diets and productivity.

3. Approaches to determining feed requirements in individual households

Agencies and farmers involved in improving feed supplies to livestock require relatively simple methods of assessing feed availability and needs. Methods presently employed tend to over-simplify the process, possibly resulting in the development of inappropriate feed resources on farms.

3.1 Current methods

Currently, feed requirements are estimated as total annual feed dry matter (DM), calculated on the basis of the total livestock units (LU) of the combined holdings of different livestock species by household. Such estimates are based on the assumed average DM intake rates of livestock units, usually supposed to be in the range of 2.5-3% of liveweight per day, resulting in an estimated annual need of 2.28-2.74 tonnes of feed DM per 250kg LU. Annual fodder supply is then estimated from the household average daily collection rate for all fodders. Annual surpluses or deficits are then estimated by difference.

This process makes a number of assumptions which may lead to inaccurate assessment of feed needs. Livestock species actually differ quite markedly in the rates of feed DM intake (in the range of 1.5% for buffalo to 5% for goats). Thus, livestock units for different species are not equivalent on a direct liveweight basis, and requirements will vary with the composition of the livestock population. Furthermore, feed DM intake rates are dependent on feed quality, livestock ages and productivity. Intake requirements for improved milk production may be well above assumed average rates.

The process also assumes that all fodders are of similar feeding value, and takes no account of seasonal differences in either supply of feeds or feed quality. Fodders clearly differ markedly in nutritive values, so that the composition of fodders available influences both the adequacy of supply and the requirements for additional feeds. Most importantly, seasonal differences in feed supply and composition are usually significant and determine the periods of peak need and the types of feeds required.

3.2 Principles in the assessment of feed requirements

Given the potential problems with over-simplified methods, it may be useful to identify the important principles before designing improved practical approaches. The primary purpose of improving feed supplies is to improve livestock nutrition and production. Therefore the assessment of need should start from a description of current feeding systems and production objectives for each livestock species separately. This approach broadly follows that outlined by Preston and Leng (1986) in 'Matching Livestock Production Systems to Available Resources'.

Feed needs should first be assessed on the basis of current seasonal feed quantities and diets, which often differ significantly in composition. Thus, the requirements to improve a crop-residue-based dry season diet will be different to those for a cut-grass-based rainy season diet.
Needs should then be assessed in relation to feasible production objectives, taking account of factors such as seasonal patterns of breeding, lactation, work, and breeds (eg crossbred vs local cattle). Increasingly, some households in favourable locations are adopting more commercially-oriented objectives for enterprises such as milk production and goat fattening, with particular feed requirements. Ideally, requirements should be considered in terms of the types of nutrients needed to

improve diets. Such assessments should be made by experienced animal nutritionists. Feeds to supply the necessary nutrients may then be identified, as far as possible.

Finally, needs should be assessed within the context of feasible interventions to improve diets; requiring that additional feeds be farm-produced at little or no cash cost (unless for market-oriented production), and within the land and labour constraints of households. To satisfy this principle, a good understanding of local land resources, farming systems and household circumstances affecting present feed supplies and demand is required.

4. Towards an improved practical method of determining feed requirements

A practical method for diagnosing feed requirements should take account of the above principles as far as possible, given the need for a simple procedure which can allow discussion between farmers and extension agents.

The components of a possible approach are:

To describe the livestock holdings and production

Count livestock holdings, and identify production objectives and seasonality of production for each species.

To describe the current feeding systems

Identify major seasons that differ in the amounts fed and the composition of diets.

For each season and livestock species, describe the daily amounts fed and composition of diets.

Identify nutrient and feed shortages.

4.1 Livestock holdings and production

The numbers of livestock of each species should be counted within major production and age groups. Thus, milking cows should be distinguished from immature cattle and calves. The conversion of different types of livestock to a common livestock unit should be avoided. For each sub-group, the main seasonal patterns of production should be identified, if consistent and important (eg cow or buffalo calving or goat kidding, cow or buffalo lactation, main work periods). For each livestock sub-group and seasonal production period, production objectives and body condition of animals should be identified (milk, growth, work, leanness etc.) and, if possible, current and required production levels estimated.

4.2 Current feeding patterns

For each livestock species sub-group, the amounts of each major type of feed offered daily should be determined. The first step in this procedure will be to identify the major 'feed availability' seasons (periods when the patterns of feed available vary

significantly). In many cases, these will break down into (1) rainy and early season, (2) mid-dry season, and (3) late dry season. Feeds allocated to each sub-group of livestock in each season should be identified, and the amounts of each feed determined if possible. This may be done by recall with some households, but could be determined in households keeping a seasonal record of amounts of feed offered. Where animals are fed in mixed-age groups, the total amounts of feed offered to the group should be estimated. Diets may be assumed to be of similar composition for each age-group within the species groups.

If it is not possible to collect information on feed quantities, an alternative approach may be taken to obtain a reliable description of diet composition (the percentage of different types of feeds in the total diet). Farmers may be better able to describe this than to quantify fodder offered to animals.

4.3 Adequacy of diets and additional feed requirements

The adequacy of diets for each livestock species sub-group and season should then be determined. This should be undertaken by an animal nutritionist, in discussion with farmers, looking at the diet composition of each sub-group of animals in relation to production objectives and animal condition in each season, and in relation to priorities between sub-groups. Required additions or adjustments to diets may then be determined and multiplied by the numbers of animals in each sub-group to determine total seasonal demands for feeds. At this stage, if quantification of the amounts of feeds offered to animals has not been possible, then amounts may be calculated from estimated DM intake rates and average liveweights for each sub-group.

Requirements for additional feeds estimated in this way then need to be compared with options for increased supply. The determination of feasible changes to diets will finally entail a balance between demand and supply. The possibilities for increased production of fodders on farms will now be discussed.

5. Options for increasing the supply of livestock feed

Livestock feed may be obtained from off-farm, or on-farm sources. The most common method of increasing off-farm supplies is to purchase feed, usually concentrates of some kind, crop residues, or green fodder from communally-, or privately-owned areas. Such sources are subject to availability and purchasing power. Supplies from off-farm grazing or fodder collection areas may be improved by changing the management to increase production, or by the exclusion of some present collectors. However, this is uncommon. Present changes in forest management are designed to increase the amount of timber and fuel available which, in the short term, frequently restrict access to grazing and reduce the amount of fodder available for cutting. On-farm sources can be enhanced by increasing the sowing rate of cereal crops, improving storage and increasing use of crop residues, and by the cultivation of fodder species. Increasing the sowing density of crops can increase the amount of crop thinnings available, or the final crop yield. Such practices are usually limited by the productive capacity of the soil, moisture availability, and cost and availability of

seed. Improved storage and use of existing crop residues have some potential as, currently, there are different levels of use and much spoilage. Cultivation of fodder species may take many forms, from the protection of wildlings (self-seeded) tree and grass seedlings, transplanting of preferred fodder seedlings from the forest, to nursery cultivation of selected species. Previously, nursery cultivation of fodder species by farmers has been by a limited number of individuals, and is a relatively new phenomenon at village level. The skills and knowledge required are not, as yet, widely spread in the farming community.

5.1 Current sources and changing patterns of feed availability

The relative importance of different potential sources of fodder can vary significantly between villages and households according to access to off-farm resources, labour availability, amount of land, ratio of irrigated to rainfed land, numbers of fodder trees and grass cultivated, and types of livestock kept.
For example, amongst the five research villages studied, off-farm fodder contribution to total fodder supply varied from a mere 8% DM in Ange to a very significant 49% DM in Gauthale over all seasons. Between household variation was also high, some reporting no use in any season, whilst a few reported a 100% reliance on off-farm sources in certain seasons. Gauthale villagers are facing a reduction in freedom of access to the communal forest areas following agreement on new communal forest management plans. This is an increasingly common situation in the mid-hills area, where access to communal forests for fodder and bedding is being reduced. Ange farmers faced this situation 4-5 years ago, and some households had to reduce livestock numbers, particularly grazing goats and cows. Despite the resultant low livestock to land ratio in Ange (lowest within the five villages) these animals were found to have the lowest levels of feed on offer. This highlights the point that off-farm grazing and fodder sources traditionally play a significant role in livestock nutrition and that loss, or restricted access to these sources, is not readily compensated for within the farming system.

Use of purchased feeds, particularly concentrates and crop residues, is increasing. Their use appears to be linked with sale of animal products, particularly milk, marketed through local milk collection points. While these fodders may successfully supplement the diets of larger ruminants, they are not suitable in large quantities for goats and cannot completely replace loss of off-farm grazing and green fodder sources.

5.1.1 Potential for increasing production of green fodder off-farm

Community management of forests has for centuries allowed substantial amounts of fodder and animal bedding to be collected, in addition to supplying timber and fuel needs for the village. Increasing population densities of people and their animals has placed increased pressure on these resources which have also suffered from changing *de jure* ownership arrangements. In some areas, heavy grazing and intensive fodder, fuel and timber collection practices have reduced previously forested land to shrub, with poor regeneration. Whilst improved management and regeneration of such land could include production of all the afore mentioned products (Tamrakar, 1993), in practice, handed-over community forest areas tend to be managed as one block and

protected for the majority of the year, to increase production of timber and fuel resources. Thus, due to institutional, rather than biological constraints, improvement of fodder resources under community forestry programmes has not been a common practice. Current survey findings indicate that off-farm fodder sources are very important in determining both adequacy and quality of ruminant diets. For example, villages with the greatest access to off-farm sources show the best quality diets (Gauthale and Gajuri Chhap), while the worst quality diets and reduced livestock numbers occur where the community forest has recently been closed (Ange). Off-farm sources of fodder are particularly important for poorer households, with less private land holdings who are less able to compensate by private cultivation, or purchase of alternative feeds. Some improvements in fodder supply have been achieved from commonly-owned leasehold land in the mid-hills (Singh 2000) and community-owned and managed grass cultivation areas are also working successfully in India. This clearly indicates that a community-based form of ownership is not necessarily a constraint to fodder resource development.

5.1.2 Potential for increasing production of green fodder on-farm

Increased cultivation of trees on farms has been a response to declining access to forest resources for over 20 years in certain areas (Carter and Gronow, 1992). Tree densities of 600, 950 and 1,400 trees per hectare are typical of heavily tree-covered sections of rainfed land (Gilmour 1988). Even more sparsely-covered areas have densities of 150-250 trees per hectare. In some lower density areas 2 to 4 fold increases in tree numbers are reported over last 15-20 years (*ibid*, Carter and Gilmour, 1989).

Significant increases in on-farm fodder supply (particularly of fast-growing leguminous trees cultivated on terrace risers) have enabled increases in the productivity and numbers of animals kept in a few small localities (New Era, 1990). Cultivation of highly nutritious grasses has been shown to be possible in the mid-hill region, but uptake has not been widespread (Campbell *et al*. 1990)

Fodder trees are preferred by farmers because less labour is required to harvest equivalent amounts of tree fodder than grass fodder, and tree fodder is available further into the dry season. Grasses, however, can be more palatable to larger livestock than tree fodders, are available for harvest more quickly after planting and contain less anti-nutritional factors.

5.2 Alternative approaches to increasing the production of animal feeds

Agencies and projects involved in promoting animal feed production have used a variety of approaches to try to increase production. These have tended to be sector-based, with the Forestry Department and forestry projects promoting the better management and cultivation of fodder tree species, the livestock sector promoting improved forage grasses and concentrate rations, and agricultural agencies promoting forage crops and some fodder grasses for cultivation on terrace risers. Whilst in combination the sectoral interventions offer a balanced approach, individually they are only addressing one or two components of livestock diets. Initial success may be achieved where the intervention has targeted correctly the most limiting feed component, but a wider consideration of all feed components is required to ensure success where feed constraints are not determined by a single component. The starting

point for interventions should be an assessment of current feeds, livestock production objectives and, hence, feed needs.

The methods employed within the various approaches to promote uptake can also have a significant impact on their success. For example projects in the past have focused on the large-scale distribution of fodder seedlings. The advantages and disadvantages of this approach are summarised in table 1.

Table 1 Advantages and disadvantages to seedling distribution

Advantages	Disadvantages
Can be made available to farmers quickly.	Fodder shortage may not as yet be identified by the farmer as a key resource constraint, leading to little care being taken of the seedlings.
	Available to only a limited number of households each year due to the expense and resources required to raise seedlings.
Available to farmers without the resources or knowledge necessary to raise seedlings.	Farmers may also have little knowledge of seedling care and management and unless necessary training or support is provided, there will be high mortality.
Initially attractive to farmers if a "free" resource.	Less care may be taken if the seedlings are free.
Can stimulate and support farmer initiatives in resource development.	Individuals may find difficulty in increasing on-farm seedling cultivation if grazing is not adequately controlled. There is a limited amount an individual can do about intensity of grazing within a village.

In general, seedling distribution programmes have been discontinued due to very high mortality rates. Some seedling distribution continues at a district level in response to individual and community forestry group requests, and these have been shown to be successful in increasing cultivation in areas close to the district nursery. Key factors appear to be farmer choice and planning for cultivation and group initiatives being accompanied by greater control of grazing, both on forest and farm land.

Seed distribution is common for grass species (those not propagated vegetatively) and is used by some agencies for fodder tree cultivation. This addresses a number of the disadvantages to seedlings distribution; a greater number of households can be reached, and the care and knowledge necessary to raise seedlings leads to better survival rates. To be successful, the approach requires greater inputs into training in nursery development for farmers, and support during nursery cultivation to ensure good survival rates.

The importance of village-level, in addition to household-level, involvement in improving fodder supplies is crucial in both approaches because of the need to agree on restricting the practice of communal grazing. This is to allow cultivated fodders on terrace risers to flourish and for households to reap the benefits of the labour used in their cultivation.

5.3 Towards an improved practical method of increasing production of fodder

A practical method of stimulating the increased production of fodder resources should take into account the above experiences within the requirement for optimising use of resources for increasing sustainable livestock production.

5.3.1 Village mobilisation

To enable improved management of fodder resources, or increased cultivation of these resources, all village members need to be aware and willing to support change. Even a small number of households continuing to practice uncontrolled grazing can destroy efforts to increase fodder resources both on and off thefarm. Where restrictions on community resources are being introduced, households not increasing private cultivation will experience shortages to a greater extent and will, therefore, experience more pressure to ignore new management plans. Consequently, it is of benefit to the whole village for all households to be involved and helped to be successful in fodder cultivation. This may also apply to neighbouring villages where paths and traditional grazing patterns involve animals from a wider area. Changing attitudes and behaviour are processes that households and individuals will experience in different ways and dialogue within the village is crucial for moving forward. Visits by village or household representatives to areas where new management and increased cultivation systems have been successfully developed can be instrumental in changing attitudes. Villages may find it necessary to introduce a penalty system to address the problem of some households repeatedly breaking new agreements with regard to restrictions on grazing. Within-household tensions may also need addressing, where responsibility for grazing animals and fodder collection lies with different individuals.

5.3.2 Identification of current fodder needs

Knowledge of current fodder sources, amounts available, proportions fed to different livestock and farmers production objectives for these livestock are necessary for the estimation of additional feed required. An improved practical method to achieve this was discussed earlier.

5.3.3 Training

Training at village and household level is required in community forest management, nursery practices, specific species cultivation techniques, grass seed cultivation and general fodder management techniques. This can be done at the village site or at a training site. Use of a training site where participants can also visit successful community forest-user groups and on-farm cultivation sites is a particularly successful approach. Representatives may attend the off-site training and then conduct training for others, with the assistance of the local support NGO, on return to the village. Encouraging the involvement of women in fodder cultivation has proved successful in providing good nursery management and survival rates. The involvement of women in community forestry initiatives is also crucial as they are usually most aware of sources and supply constraints, as the household members primarily responsible for fodder collection.

5.3.4 Cultivation and management

While training may be given to individual household members, awareness and planning of forest management plans and on-farm cultivation needs to be shared among members of the household to ensure that the newly-planted fodder resources are protected. At farm level, the siting of new cultivation sites needs to be planned, so as not to interfere with crop cultivation through root interactions or excessive shading.

5.3.5 Monitoring performance and trials

Monitoring of the survival and growth of different species under varying environmental conditions is very important for optimising local planting patterns and in developing and advancing the information available for training other farmer groups.

For optimising local-planting techniques, monitoring of species performance as they are distributed by households over their farm, or forest is usually adequate, so long as sufficient numbers of each species are planted. Differences in survival and species growth rates in different locations become apparent over time, and farmers then adjust subsequent plantings to copy more successful previous experiences.

In order to obtain information that will be of use in other areas a more structured approach is required to identify not only factors influencing survival and growth, but their degree of influence and possible interactions. In this case, more formalised and structured trials are required to monitor survival and growth under clearly identified conditions of altitude, aspect, soil type, fertility status, seedling density, seedling age and management practices. An example of how this can be done on-farm is given in a later paper.

6. Estimating potential increases in fodder production on-farm

There is little information available on the extent to which on-farm fodder planting can address fodder needs, or support future increases in livestock production. Speculation ranges from on-farm fodder cultivation only proving an answer to deficits for those with the largest land holdings, to being a panacea for all, because of reduced pressure on communal fodder resources. From the initial findings of the project, we attempt to estimate the potential increases in production of on-farm fodder at village level.

6.1 *Potential increase in fodder production on-farm through cultivation*

Examples are taken from the systems chosen and employed by farmers at the five research sites. Farmers generally chose to plant a mixture of exotic and indigenous fodders. Exotic species were selected for their early productivity, an important consideration where deficits are acute, ease of management to reduce impact on adjoining crop growth, and because of seed availability and ease of cultivation. Indigenous trees were selected for greater overall production per tree when mature, longer survival and farmer familiarity with their management and fodder quality characteristics.

The project is just beginning to collect information on production levels from the fasted growing species, however this is for very young trees. Figures for fodder production have therefore been taken from a range of other studies (see table 2).

Table 2 Average production (kg fresh weight) at approximately 3-4 years (trees) and dry weight for grasses.
Production levels for species marked with # are for individuals grown along terrace risers and cut several times a year.

Species	**Fodder per year Kg (fresh weight).**	**Location**	**Reference source**
Leguminous trees			
Leucaena diversifolia	10 #	0-1200m Cut 2-3 times a year	**
Leucaena pallida	5 #	1000-1800m cut 2-3 times a year	NAF staff
Bauhinia purpurea	8.75	500m	***
Flemengia congesta	8.75 #	0-1200m cut 2-3 times a year	**
Trees			
Morus alba	10 #	0-1200m Cut 3-4 times a year	**
Guazuma ulmifolia	11		***
Artocarpus lakoocha	35		*
Ficus semicordata	17.5		***
Grasses	**Kg (dry weight)**		
NB 21 rainfed	0.12	Rainfed land	*
NB 21 irrigated	2.0	Irrigated land <1200m	*

NB21=Penniseteum purpureum x Penniseteum americanum

*Summarised from HLFFDP (1997) Fodder and Pasture Research and Development in Nepal. Main text, Vol I, Hills Leasehold Forestry and Forage Development Project.
**Nepal Agroforestry Foundation (NAF) (1997) Agroforestry trainers' training manual
***Banko Janakari

6.2 Estimating potential fodder production from fodder species planted in 1998 and 1999 seasons across the five research sites

The number of seedlings of each of the different species planted in 1998 and 1999 and their survival has been monitored. The figures for two years are presented separately to show different uptake rates (uptake was more rapid in Gauthale and Gajuri Chhap than other locations), and the change in species cultivated in the second year, based on farmers' experiences in the first. Multiplying surviving seedling numbers by production figures from table 2, estimates of potential tree fodder production are presented in table 3.

Table 3 Estimate of total production (kg dry matter) of tree fodder at 4 years from seedlings planted in 1998 and 1999 and still surviving in the following year.

Village	Year	Leguminous tree fodder		Other tree fodder		Total tree fodder
		total	per household	total	per household	Per household
Gajuri Chhap	1998	6113.0	611.3	1530.9	153.1	764.4
	1999	4436.5	443.7	2775.6	277.6	721.2
Gauthale	1998	7540.3	754.0	980.0	98.0	852.0
	1999	6424.5	642.5	7612.7	761.3	1403.7
Chunkhubesi	1998	1641.9	164.2	2.5	0.3	164.4
	1999	942.3	94.2	4963.2	496.3	590.5
Tawari	1998	476.4	47.6	0	0	47.6
	1999	1925.7	192.6	5627.6	562.8	755.3
Ange	1998	565.0	56.5	1506.8	150.7	207.2
	1999	1361.1	136.1	5099.6	510.0	646.1

Production from grasses is very dependent on the amount of moisture available. NB21 slips were introduced in 1998 and their survival monitored. Estimates of production under irrigated and drier rainfed conditions are given for numbers of slips known to be planted in 1998 and surviving in March 1999, in table 4.

Table 4 Estimate of production (kg dry matter) of grass fodder under irrigated and rainfed conditions from slips planted in 1998 and still surviving in March 1999.

Village	Grass under rainfed conditions		Grass under irrigated conditions	
	total	per household	total	per household
Gajuri Chhap	16.5	1.6	274.7	27.5
Gauthale	9.5	0.9	158.2	15.8
Chunkhubesi	0.0	0.0	0.0	0.0
Tawari	0.0	0.0	0.0	0.0
Ange	3.6	0.4	60.5	6.1

6.3 Farmers' perceptions of deficits across all villages.

While farmers appeared confident and clear about experiencing fodder deficits (% households reporting deficits), quantification of the deficit was found to be difficult. Consequently, deficits appear to be over estimated, when compared with amounts fed by farmers not experiencing deficits in the same season. An alternative approach to estimating deficits is to compare collection rates between households experiencing deficits, with those that are not, adjusting for livestock units. The complications this introduces into the estimates are discussed in a later paper, and for the current broad-based estimates, farmers' perceptions of deficits are referred to in table 5.

Table 5 Total average deficit in kg dry weight per year per household, and deficit per area of land

	Gajuri Chhap	Gauthale	Chankubesi	Tawari	Ange
Crop residues	2587.2	2469.6	1344.0	2721.6	2570.4
Cut grass	3250.8	2693.3	2173.5	2494.8	2825.6
Tree fodder	2149.9	2675.4	1258.1	1576.6	1401.4
Crop residue per ropani[1]	52.1	99.1	63.8	95.8	99.1
Cut grass per ropani[2]	114.2	167.7	160.7	126.0	191.4
Tree fodder per ropani[3]	115.5	245.2	161.6	128.2	238.1

[1] Ropani, total cultivated land in one year (cultivated land x cropping frequency).
[2] Ropani, total land holding (rainfed and irrigated and non-cultivated land).
[3] Ropani, area of rainfed land only.

6.4 Comparing estimated deficits with potential fodder production on-farm

Comparing potential production (tables 3 and 4) with deficit perceptions (table 5), production met between 2% (Tawari) and 20% (Gauthale) of tree fodder deficits in the first year and in the second year between 15% (Gajuri Chhap) and 21% (Gauthale). Survival rates were particularly low in the first year at Tawari (just 10% for *Leucaena diversifolia* and 18% for *Flemengia macrophylla*) due to the very dry year and the unsuitability of these species for this frost-prone area. Use of different species (such as *Leucaena pallida*) in subsequent years it is hoped will show better survival.
There is less information to date from the project on production from the grasses, as farmers have been managing their new species for seed and propagation by vegetative material. Monitoring sowing and survival of grass seed is more difficult and has only been possible so far for NB 21 cuttings provided in the first year. Taking values from hill research farm, production from these varies ten fold, according to whether they are grown under rainfed or irrigated conditions. Production varies from 0.1%(Ange) to 0.6%(Gajuri Chhap) of grass fodder deficits under rainfed conditions to approximately 2%(Ange) to 9%(Gajuri Chhap) under irrigated conditions. Future monitoring of grasses that have now come into production will provide further information.

These data indicate that even with very intensive planting activities as undertaken in Gauthale and Gajuri Chhap, it would take approximately four years of continuous planting of fodder trees at current rates to address perceived deficits. This increases to 7-9 years for sites with lower planting rates. (A certain degree of mortality after the first year is to be expected, off-setting the over-estimate of deficits.) Such calculations assume that households are able to cultivate the number of seedlings and cuttings that they require. Whilst some farmers experience no serious limitations to cultivation, others reported raising less seedlings than they would have liked, even in the first year of cultivation, due to land limitations. On-farm cultivation is definitely an important response to feed shortages, and can be increased by suitable support, however, it has a relatively long time horizon. Furthermore, it is only able to address a proportion of shortages for farmers with smaller livestock to land ratios.

7. Conclusions

In view of the changing circumstances affecting the supply and demand for feeds there is a need for research to identify major determining factors and trends. Such research faces key problems, such as the strong seasonality of supplies, wide range of feeds used, allocation to different livestock and a variety of household factors. Household factors include land and tree holdings, livestock numbers and labour availability. A combination of qualitative, discussion-based methods and more quantitative measurements is recommended to undertake this analysis. Repeat visits are necessary to collect reliable quantitative data and are also valuable in building a rapport and information exchange with farmers. Current methods of feed need assessment tend to be based on total livestock units, rather than differentiating between species. As species differ in their rates of DM intake, and DM intake is dependent on livestock age and productivity, an inaccurate assessment of feed needs may be made. An improved, practical method of determining feed needs is required which takes account of livestock holdings and production, current feeding patterns, adequacy of diets and additional feed requirements.

Livestock feeds may be obtained from off-farm or on-farm sources. The relative importance of different sources can vary significantly between villages and households according to access to off-farm resources, labour availability, amount of land, ratio of irrigated to rainfed land, numbers of fodder trees and grass cultivated, and types of livestock kept. Use of purchased feeds, particularly concentrates and crop residues, is increasing. Their use appears to be linked with sale of animal products, such as milk, marketed through local milk collection points. While these sources may successfully supplement the diets of larger ruminants, they are not suitable in large quantities for goats and cannot completely replace loss of off-farm grazing and green fodder. Whilst there appears considerable biological potential for increasing production of green fodders from off-farm sources, institutional constraints are at present limiting this option for many farmers. Farmers are independently increasing the amount of fodder grown on-farm and utilisation of crop residues in response to fodder shortages. Lack of planting materials, and in some cases knowledge of cultivation, are identified as constraints. Storage methods that reduce spoilage in crop residues and preserve surplus fodders during the monsoon are required. Previously, narrow sectoral approaches to meet feed needs have led to unbalance , with either tree fodder, or forage grasses being promoted. An improved practical method of increasing the availability of fodder resources is required that involves village mobilisation, identification of local fodder needs, training at village and household level, development of new management and cultivation plans, and on-going monitoring and evaluation of activities.

Research findings indicate that whilst some farmers could cultivate sufficient to meet current needs within four to five years, others raise less seedlings than they would like, even in the first year of cultivation, due to land limitations. Land type and size in relation to livestock holdings is a key constraint in the extent to which on-farm cultivation of fodder can answer the fodder shortage problem. Further investigation is required to determine the proportion of households that face land constraints, and their characteristics. Off-farm sources of fodder will remain very important for such households and ways of maintaining and increasing supplies from these sources needs investigation.

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