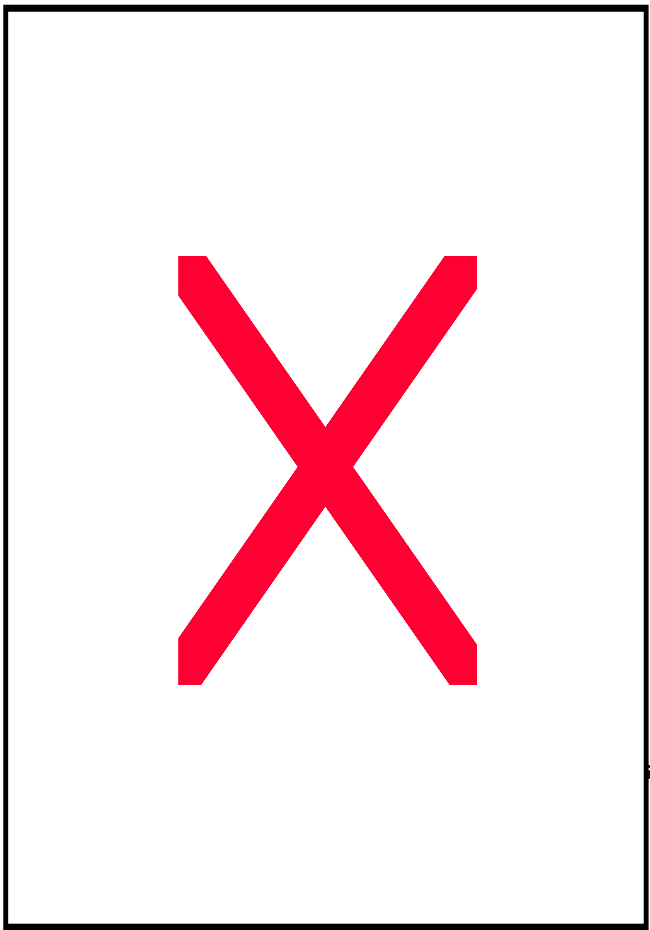
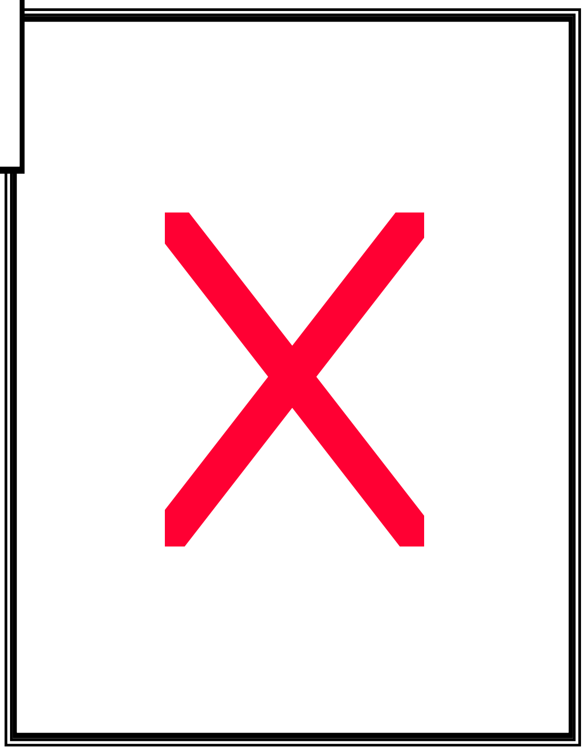
Livestock Production Systems and the Development of Fodder Resources for the Mid-hills of Nepal





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GLOSSARY OF NEPALI TERMS

Nepali	Definition
Bari	Rainfed land that receives no additional water.
Bhari	One back-load of material (weight varies depending on material, who's carrying it, location and time of the year).
Doko	Local back-carrying basket
Gharbari	Land close to the household
Ghee	Clarified butter
Haat	Local market
Kharbari	Rainfed land unsuited to crop growing that is used to grow thatching grass.
Khet	Land that is bunded and receives some additional water during the dry season. Supports two, or three crops per year
Kusauro	legume residues
Nal	millet straw
Obanopan	Fodders that are highly palatable and satisfy hunger in ruminant animals.
Pakho bari	Sloping, rainfed land
Posilopan	Fodders that promote milk and butter fat production in lactating animals, rapid live weight gain and animal health.
Ropani	0.05 (one twentieth) of a hectare

Species names

Nepali name	Botanical name
Abijalo	*Drymaria diandra*
Amale	*Embilica officinalis*
Amliso	*Thysanolaena maxima*
Armale jhar	*Anagallis arvensis*
Arthunge	*Heteropogon contortus*
Badahar	*Artocarpus lakoocha*
Bakaino	*Melia azedarach*
Bakimilo	*Rhus semialata*
Banmara	*Euphatoria adenophorum*
Bans (Choya)	*Dendrocalamus hamiltonii*
Bans (Mal)	*Bambusa mutans*
Banzpate	*Rumex dentatus*
Bhakimlo	*Rhus semialata*
Bhatmase	*Flemengia congesta*
Bhimsenpati	*Buddleja asiatica*
Bilaune	*Maesa chisia*
Buletro	*Butea minor*
Chilaune	*Schima wallichii*
Chiple	*Machilus gamblei*
Chuletro	*Brasaiopsis hainla*
Dabdabe	*Garuga pinnata*
Dhalne katus	*Castanopsis indica*
Dhangero	*Woodfordia fruticosa*
Dhudilo	*Ficus nemoralis*
Dinanath	*Pennisetum pedicillatum*
Dubo	*Cynodon dactylon*
Gayo	*Bridelia retusa*
Gedulo	*Ficus clavata*
Ghurbis	*Leucosceptrum canum*
Gogan	*Saurauia napaulensis*
Guazuma	*Guazuma ulmifolia*
Gunyalo	*Eliagnus latifolia*
Ipil	*Leucaena* spp.
Juwane jhar	*Fimbristylis miliacea*
Kabro	*Ficus lacor*
Kali Lahara	*Marsdenia tinctoria*
Kamle	*Pilea symmeria*
Kamuna	*Streblus asper*
Kane	*Floscopa scandens*
Kangiyo	*Grevillea robusta*
Kans	*Urticularia bifida*
Katus	*Castanopsis hystrix*
Kaulo (Laphe)	*Machilus odoratissima*
Khanue (Kasre)	*Ficus semicordata var. montana*
Khanue (Rai)	*Ficus semicordata var. semicordata*
Khari	*Celtis australis*
Kharuki	*Pogonatherum incans*
Khasreto	*Ficus hispida*

Khorsane	*Pittosporum napaulense*
Kimbu	*Morus alba*
Kode jhar	*Eleusine indica*
Koiralo	*Bauhinia variegata*
Kurkure	*Blumea lacera*
Kurro	*Bidens biternata*
Kutmero	*Litsea polyantha*
Kutmiro	*Litsea monopetala*
Lapsi	*Choreospondis axillaris*
Latte sag	*Amaranthus viridis*
Mahuwa	*Madhuca latifolia*
Maleti	*Mazur pumilus*
Molasses	*Melinus minuutiflora*
Mothe	*Cyperus rotundus*
Napier	*Pennisetum purpureum*
Nebaro	*Ficus roxburghii*
Painyu	*Prunus cerasoides*
Patle	*Castanopisis hystrix*
Phaledo	*Erythrina aborescens*
Phurke	*Arundineria falcata*
Phusre	*Lindera pulcherrima*
Puruni Ko Lahara	*Cissus repens*
Ratnaulo	*Bistorta amplexicatus*
Sama	*Echinocloa cras-galli*
Sava	*Diplocyclos palmatus*
Sayapatri	*Tagetes erecta*
Siru	*Imperata sp.*
Sisno	*Urtica dioca*
Stylo	*Stylosanthes guianensis*
Syalphusre	*Grewia oppositifolia*
Tanki	*Bauhinia purpurea*
Timila	*Ficus auriculata*
Titepati	*Artemisia vulagaris*
Unue	*Dryopteris fillix-mas*
Utis	*Alnus nepalensis*

List of Abbreviations

AAN	Action Aid Nepal
BTRT	*Begnas Tal Rupa Tal*
CEAPRED / Nepal	Centre for Environmental and Agricultural Policy Research Extension and development / Nepal
COSIS	Centre for Integrated Agricultural and Cooperative System
CPR	Common property resource
DfID	Department for International Development
ECCA	Environment Camp for Conservation Awareness
FFI	Feed fluctuation index
FORESC	Forest Research and Survey Centre
FUG	Forest User Groups
FYM	Farm yard manure
GSBS	*Gramin Samudaik Bikash Sanstha*
ILCA	International Livestock Centre for Africa (now assimilated into the International Livestock Research Institute)
LSU	Livestock unit
m.a.s.l.	metres above sea level
NAF	Nepal Agroforestry Foundation
NGO	Non-governmental organisation
PRA	Participatory rapid appraisal
SAGUN	Social Action for Grassroots Organization
SDC	Swiss Development Cooperation
SEARCH / Nepal	Service Extension and Action Research for Communities in the Hills
sq. km.	Square kilometres
TDN	Total digestible nutrients
TLU	Tropical livestock unit
UNDP	United Nations Development Programme
VDC	Village Development Committee

Preface

The review seeks to bring together information from Nepal, with reference to livestock production systems elsewhere, to further understanding of the nature of constraints to livestock production in the Mid-hills of Nepal. Opportunities for improvement of production are considered, drawing on research and extension findings, and the experience of NGO's working in the field.

The review is an output from a DFID funded research project within the Livestock Production Program, which seeks to identify improved livestock feed strategies using participatory research techniques. It is intended for use by research and extension staff in the field of fodder development, providing an overview of the subject that was identified as lacking. Authorship is shared by the Department for Forest Research and Survey (HMGN), Nepal Agroforestry Foundation (National NGO) and the Natural Resources Institute (UK), the three institutions involved in implementation of the project. Additional literature investigation was conducted by Anjana Giri and Rekha Kharel (DFRS).

Summary

Livestock are a crucial component of the hill farming system in Nepal. They contribute to household subsistence and incomes, draught power and the recycling of nutrients essential for the fertilisation of cultivated land. Traditionally, communal grazing areas and off-farm fodder resources have been important for the nutrition of ruminant livestock. Increasing pressure on land, together with changing access rights to some communal resources, has led to a decrease in the availability of off-farm fodder resources. Seasonal feed shortages are becoming more severe and farmers report this as limiting livestock productivity in many areas. Poorer community members are particularly affected by these shortages because of their limited private land holdings and less ability to supply, or buy, supplementary feeds and chemical fertilisers.

The review considers the development of farming systems and the integrated nature of resource management in the middle hills of Nepal in the context of the agroecology, land ownership and access to common property resources. Livestock production systems are characterised and their interdependence with, and importance in the support of, cropping systems is outlined. Current knowledge with regard to forage resources is summarised in terms of key feed resources, factors affecting feed supply and utilisation and the potential that exists for their further development. A short introduction to current research and extension activities by NGOs involved with communities in the development of fodder resources completes the review.

Feed shortages and/or poor quality fodder at the end of the dry season in March-June are a particular constraint to livestock production. These shortages affect milk production, adult and calf health, calving rates, the condition of draught animals and livestock numbers. In the largely organic-based farming systems in the hills, manure

produced by animals is vital for the maintenance of soil fertility. A decline in soil fertility has been linked with decreasing numbers of livestock in certain areas which, in turn, has been caused by the lack of readily-accessible fodder.

Traditionally, fodder has been gathered in the form of tree leaves and grasses from common property forest areas, which are guarded and managed by the local community. These off-farm sources are particularly important in the dry season, providing a high protein supplement to low protein crop residue diets. A small amount of tree fodder is harvested on-farm from planted trees, protected wildlings, woodlots, terrace-risers and field boundaries. Studies show that an increase in on-farm cultivation of fodder trees is associated with diminishing community forest resources. More recently, the tightening of rules with regard to access to community resources has necessitated more on-farm cultivation of fodder, both in terms of grasses and trees. As traditional community resources diminish, the labour and time required to collect fodder from off-farm sources increases. Hence, the cost/benefit ratio for private cultivation increases.

Larger landowners can afford to set aside some land for fodder and tree production, avoiding potential competition with crops and making protection of the young trees, grasses and legumes easier. Larger land holdings also enable farmers to be less dependent on off-farm resources. Farmers with limited land resources cannot afford to take land out of crop production in this way, and it is for smallholder farmers that integrated tree/grass/legume/crop systems are of particular relevance.

Many NGOs are actively involved in the promotion of private tree and fodder cultivation through support and training for local private and community nurseries. Their activities are in response to a demand from some smallholder farmers for suitable planting materials. While increasing private cultivation of fodder is an option and possible solution for some farmers, it is unclear whether this is feasible for all farmers. The degree to which fodder deficits are due to a shortage of basal feeds and /or high protein supplements needs clarification.

There are two non-biological advantages to on-farm fodder cultivation; labour saving at peak work times of the year and reducing the risk in collection of tree products. Accidents incurred while collecting tree products, particularly fodder, are the most common cause of injury in rural areas of Nepal. Seasonal labour shortages around planting and harvesting are common, so easily accessible on-farm fodder resources are especially valuable during these times.

Introduction

In the Mid-hills (1100-1700m above sea level; m.a.s.l.) farmers manage a fragile hillside environment to meet their own needs and to preserve available resources for their descendants. Livestock, often viewed by the less well-informed as an unremitting enemy of sustainable production, play a key part in the farming system. In particular, they provide draught animal power for cultivation and transport and, perhaps most importantly of all, are responsible for the production of manure which underpins the farming system. Manure, as a direct addition and in association with waste green materials in compost, delivers nutrients to crops in an accessible form and helps maintain soil structure. In addition, animals produce valuable commodities such as meat and milk and generate cash income. It is not uncommon for farmers to indicate that farming the Mid-hills without the current level of integration of livestock would not be feasible. Certainly, even with favourable financial indicators, the mechanisation of cropping on terraced slopes and the widespread introduction of high levels of inorganic fertilisation on farms that may be several days from a road are unlikely ever to be technically feasible.

Human population densities are high and continue to increase in the Mid-hills, which places considerable demand on the capacity of the farming systems to produce food. This has required increased productivity and intensification in crop production systems which, because of the key contribution made by animals in underpinning them, has impacted on livestock in two, major ways:

- the need for increasing quantities of organic soil adjuvants in particular has tended to drive either increases in livestock population densities in extensive systems, or decreases in association with stall feeding and intensification (Thapa *et al.*, 1990);
- reductions in common property access to forests and grasslands, traditionally important sources of fodder, has reduced the overall availability of feed resources (Campbell *et al.*, 1990).

Any consideration of the fodder supply situation must be holistic and dynamic in view of the highly integrated nature of the systems and the pronounced seasonal climate of the Mid-hills. Animal diets consist of a number of constituents including grasses, crop residues, concentrates, herbaceous plants and tree/ shrub fodder. Availability fluctuates over different seasons and, consequently, fodder deficits vary in type and quantity over the year. Interventions to address these deficits must take note of their specific character in different locations and for different households.

In many areas, farmers themselves have responded to the fodder supply problem by initiating on-farm plantings of some of the preferred species that have traditionally supplied fodder from forests. On-farm plantings of these or other species is particularly relevant for poor farmers with small land holdings and limited access to forest or grazing resources. Potentially, it allows them to improve the productivity of the terrace-risers that may, on some farms, account for almost 50% of the land area and those areas that are not suited to subsistence or cash cropping.

This review has been commissioned by the Department for International Development (DfID) and forms part of the research project (R6994) entitled “Strategies for improved fodder production in the dry season in the Mid-hills of Nepal, using participatory techniques”. It aims to bring together at least some of the eclectic and dispersed literature on fodder sources and their utilisation for livestock production in the Mid-hills, and to synthesise this with relevant information from the wider, scientific literature, in order to support the information needs of the project.

Farming Systems and Integrated Resource Management in the Mid-hills

The Agro-ecology of the Mid-hills

The hill region of Nepal, as distinct from the *Terai* situated on the northern Gangetic Plain and the barren, high *Himal,* is divided into two physiographic zones, the Mid-hills and High-hills (Figure 1). In total, the region covers approximately 73,000 sq. km., 49% of the total land area, and comprises 44,000 sq. km. of middle mountains and 29,000 sq. km. of high mountains (FRIS, 1994). The hill region, as a whole, falls between latitude 27-30 degrees North, and covers an altitude range of between 200 and 4000 m.a.s.l. The Mid-hills include the most heavily populated central belt of Nepal. They may be characterised as a network of ridges and valleys, with less than 5% of the land area level. Altitudes range from 200 m.a.s.l. in the river valleys of the east to 3000 m.a.s.l. on the ridges close to the high mountains. Long and intensive use of the land for agriculture is reflected in the extensive terrace systems and heavily utilised forest and grazing areas. The high mountain areas are defined by the extent of habitation, rather than absolute altitude, and may reach as low as 1000 m.a.s.l in isolated valleys although averaging 2300 to 3000 m.a.s.l. on ridges. The hill region is bordered to the north by the high *Himal*, defined as starting at the limit of forest vegetation (4000 m.a.s.l.). Alpine meadows extend up to 4500m in some areas and are an important common property resources (CPRs) for transhumant livestock. The Mid-hills are bordered in the south by the *Siwaliks*. The *Siwaliks* are distinguished by their steep-ridged character and coarse-textured, stony, shallow soils that make them largely unsuitable for cultivation (HMGN, 1988).

Rainfall in the hill region is variable, between 1150 and 4180 mm *per annum*, with a distribution that is both seasonal and geographical. The heaviest concentration of rainfall occurs during the monsoon season that lasts from mid-June to mid-September. The remaining eight months of the year are usually dry (Sharma and Subedi, 1994). The western part of the country generally receives less rainfall as the south-western monsoon starts earlier and finishes later in east. Throughout the country, conditions tend to be drier on more exposed southern slopes. Temperature ranges are also large, with monthly means of 2.6 °C -3.8 °C in winter and reaching a maximum 41 °C in summer. Localised frosts, which may limit cultivation, occur in pockets and at higher altitudes.

In the Mid-hills, much of the land is not cultivated and is under grazing and forest. According to Shrestha and Pradhan (1995), 40% of the cultivated land of the country is in the Mid-hills, 31% of the grazing land and 50% of the forests. A further 32% of what is classified as “other” land is also found in the zone. Traditionally, the majority of Nepalese have inhabited the Mid-hills because of the equitable climate for human, animal and crop health and for arable cultivation, and because the network of valleys and ridges constituted readily defensible positions.

Land ownership tends to be more equitable in the hills than on the *Terai.* However, farm sizes are very small. The average land holding is around 1.12 ha, but the distribution is skewed with over 60% of farm households owning less than 1.0 ha. The average land held on these smallest farms is, in fact, less than 0.5 ha (IDS, 1985). In spite of their small size, land holdings are often scattered over a considerable area and altitude range as most farm households own areas of irrigated, rainfed and higher altitude land. This allows, at the expense of some increase in managerial complexity, the cultivation of a range of crops and reduces the risk resulting from flooding of lowlands, or landslide destruction of uplands (Carson, 1992).

The agricultural systems are dependent heavily on forest products, both directly as a source of nutrients through fodder and leaf litter and indirectly as fuelwood, food, medicine and construction materials. Consequently, forests are used widely. Confusion resulting from recent changes in tenure and rights of harvest from these traditional CPRs has led to over-exploitation and unsustainable harvesting in some areas. Indeed, tenure of both agricultural and forest lands is an important and far-reaching factor influencing the general decision-making of farm households and their planning of resource management strategies.

Land Ownership, Tenure and Common Property Resources

Land Ownership, Tenure and their Implications for Management Practices

The history of land ownership and tenancy rights in Nepal closely follows political developments. Land reform policies were introduced from 1951 as part of a package of social and economic reforms by the new government, at the end of the Rana regime. Early reforms, motivated by a fear of agrarian revolution starting in the western *Terai*, sought to offer greater security of tenure, regulate the rents paid to landlords and prohibit further extraction of money and labour from tenants. Restricted to the *Terai*, this legislation redefined the tenant - landlord relationship, rather than changing the structure of the agrarian system. Regmi (1976) reasons that reforms to the tenancy system alone cannot insure that the productive capacity of the land is fully realised, because of an unequal distribution of costs and benefits of production. Traditionally, the tenant bore all costs of production, while returns were shared with the landowner. With land rents set by the Land Reform Act of 1964 at 50% of the gross product, the cost-benefit ratio for financial or labour investment in additional fertiliser application by a tenant would be half that for an owner-cultivator.

Such theoretical predictions of the effects of land tenure systems on soil fertility management practices are supported by the higher yields observed under owner-cultivation (Zaman, 1972 cited in Regmi, 1976). Perhaps in response to poor yields from tenanted farms, landowners have begun to supply the chemical fertilisers, favoured by tenants as a "free" input for giving quick returns (Tamang, 1993). Tenants with little security on the land they cultivate and, consequently, little vested interest in the long-term productivity, may favour the use of chemical fertilisers to the detriment of longer term soil productivity. Greater investment was found in terms of application of compost, green manure and mulch by owner cultivators, who are assured of both the short and long-term effects of their investment (Tamang, 1993).

More far reaching reforms were introduced between 1964 and 1966. These included the imposition of a ceiling on land holdings. This ceiling, together with rent control measures, sought to reduce returns from investments in land so as to divert capital to finance new industrial developments. Such a potentially radical move against the elite followed the return of the monarchy in 1960 and was supported by international political and economic interests, particularly the USA. International support was motivated by fears that tenant unrest might support the spread of communism in the region.

The impact of the reforms was blunted by the relatively high ceilings set for land holdings. These were 4.1 and 1.1 ha, respectively, for landowners and tenants in the hills, compared to the present average holding of 0.4 hectares for a family of between five and six members. Furthermore, the high share of production (50%) appropriated by landholders, compared to below 25% in India, the Philippines, Sri Lanka and Thailand continues to influence the management practices employed by the cultivator.

Generally, quick returns are required by tenants to meet their subsistence requirements. This, and the relatively insecure nature of tenancy-cultivation, inevitably leads to management decisions with a short-term focus. As a result, long-term investments in the land (such as optimum terracing, the planting of trees and trash / grass bunding to prevent soil erosion) may not be considered. Tree planting, in particular, may also be discouraged because of rights and ownership status associated with the practice.

Common Property Resources (CPRs)

CPRs may be defined broadly as those resources in which a group of people have co-equal use rights (Jodha, 1991). In Nepal, these include the important resources of community forests and scrubland, community pastures, wastelands, watershed drainage, village ponds, rivers, streams and their banks. CPRs contribute to subsistence livelihoods, employment, income generation and asset accumulation. They complement private farming activities, providing organic matter for compost and green manure, animal feed and bedding, and are particularly important at times of economic hardship. A four-year field study by Jodha (1991) of 82 villages from 21 districts in the dry tropical zone of India emphasises the potential importance of CPRs. Between 31 and 42% of total farm inputs during the study period were derived, in cash or kind, from CPRs.

There would appear to be considerable differences amongst locations in levels of dependence on CPRs for fodder supply. In two separate studies conducted in the Central Region of Nepal, Pandit (1994) and Neupane (1995) found that between 25 and 30% of fodder was collected from sources beyond farm boundaries. In contrast, Shah (1980) has suggested that up to 85% of fodder may come from off-farm sources. Within a given area, households are likely to differ in the extent of their reliance on CPRs. It is perhaps not surprising that resource-poor households have been found, generally, to rely on off-farm resources to a greater extent than the relatively resource rich.

In considering CPRs, it is important to distinguish resources that are used and managed by a distinct group of people from resources that have no restrictions placed on their use (open access resources). The pessimistic prognosis of Hardin (1968) for the "tragedy of the commons" argues that degradation of commonly-held property is inevitable because of the economic advantages to the individual of increasing their share, while an individual is unable to control over-exploitation by unilateral action. However, in the case of community-managed CPRs in Nepal, individuals do act to preserve resources. A number of factors acting together positively reinforce active management in these situations. Limited group and resource size enables members to effectively police use of the resource. The strong sense of membership of a common and interdependent community, together with shared knowledge and trust between users, leads to high levels of social capital being present. The community values are dependent on both the resource and group cohesion; factors that over-ride the short term economic rationale of individual over-exploitation.

Traditional CPR management arrangements in Nepal have provided relatively sustainable and equitable access to forest areas for centuries. However, the CPR base has changed and, in many cases, has been restricted in area or accessibility. Generally, this situation has resulted less from the nature of CPR management than from the burgeoning demands of an expanding population. Reductions in the size of land-holdings alongside this increased demand have compromised what were, traditionally, sustainable land management practices; soil productivity has declined and reduced returns to labour inputs accrued. Such vicious circles build up in various areas of agricultural activity. The need for increased levels of production leads to an expansion in livestock populations. The resulting higher demand for fodder and access to grazing leads to greater use of CPRs, eventually exceeding their regenerative capacity. This inevitably leads to degradation, with reduced resource availability, including that of fodder and leaf litter for composting, which in turn leads to increased rates of erosion and reduced soil productivity.

The Farming Systems of the Mid-hills

Farming systems in the Mid-hills are mixed, diverse and subsistence orientated, in which there is a close interaction between crops, animals and forests. Crop production is very dependent on livestock for manure and draught power, and is practiced mainly on terraced slopes. Crops produced include rice, maize, millets, wheat, soyabeans, barley and pulses. Vegetables, fodder trees and fruit trees are grown widely. Cash crops are scarce. Both single and multiple cropping are undertaken. Examples of cropping systems in the Eastern hills are:

High-hills (1700-2300m) on *Bari* (rainfed) land- potato+maize; maize+soyabean.

Mid-hills (1100-1700m) on *Bari* land- maize followed by millet.

on *Khet* (irrigated) land- maize followed by rice.

Low-hills (<1100m) on *Bari* land- maize followed by millet; or groundnut-fallow.

on *Khet* land- rice followed by rice; or wheat followed by wheat.

The application of systems analysis to farms has provided useful insights in assessing the relative efficiency and productivity of different agricultural enterprises (system components), and identifying the key constraints to production. Farms may be viewed from a systems perspective because several activities taking place in them are closely related to each other by common use of labour, land and capital, by risk distribution and by their joint use of the management capacity of the farmer (Ruthenberg, 1980). Any system may be defined by a boundary which separates it from the wider environment. However, in the Mid-hills, the definition of such a farm boundary is often complicated by the heavy reliance on more widely-dispersed communal resources for grazing and forest products.

A Historical Perspective

The hill farming systems of Nepal are the oldest and, in many cases, the most complex and interdependent systems in the country. They consist of a mixture of practices developed over time by different groups and have evolved and continue to evolve, *in situ*, under increasing population pressure. Cultivation of the hills was initiated by migrating tribes of mongoloid origin, believed to have moved into the area from the north across the high *Himal* (Ghimire, 1992). Initially, low population densities meant that sufficient resources were available for the practice of subsistence swidden (slash and burn) agriculture. Wet rice cultivation and the use of bunds, ploughs and irrigation were introduced by Indian refugees in the eleventh and twelfth centuries. The metal weapons introduced at the same time enabled the newcomers to dominate the existing social structure of tribal chiefdoms and to appropriate many of the fertile, lower hill and valley areas for irrigated rice production. The greater productivity, made possible from use of irrigation, secured a more powerful economic position for these immigrants. The new Hindu rulers consolidated and maintained this position through the extension of the caste system into tribal areas, and by extraction of taxes from both the new and original cultivators.

Official land ownership at this time was removed from cultivators and given to members of the royal family, the nobility, senior civil and military people and religious institutions. Previous ownership patterns among the hill tribes were community based, with land held by the local chief and rights of cultivation given to community members according to their needs. Generally, land was not inherited by individuals although the use of land could continue in the same household from generation to generation. Under the land-grants system, owner-cultivators were reduced to tenants or sharecroppers, and were encouraged to extend cultivation to increase revenue for the state and its representatives. However, the extraction of higher land taxes, together with labour tribute, acted as a disincentive to the production of surplus and the cultivation of new lands (Regmi, 1976).

Mahat *et al.* (1984) and Mahat (1987) present evidence that land-use boundaries in the hills have remained largely unchanged for several centuries, with population pressures leading to additional exploitation and degradation of remaining forest areas, but not a conversion of forest land to agriculture. The response to population pressures and the need for greater production has been to diversify livelihoods and intensify cultivation, rather than to make them more extensive. This is illustrated by the widespread presence of uncultivated terraces in the higher hill regions, where past efforts to extend cultivation in order to increase production have been abandoned. It would appear that returns to labour from these marginal lands are just too low.

Rather conflicting evidence is presented by Zurick (1990) in a micro-level study of land use changes in *Phalabang*, a Mid-hills village in Rapti zone, conducted from 1953 to 1985. This study shows a small increase in areas of *khet* land (11%), a slightly larger expansion of *bari* land onto formerly open lands (17%) and a large expansion in the area of grassland (630%). Grassland expansion was the result of a "roll-back" process, whereby mature forest (-24%) has been degraded to shrub-land (-30%), which in turn was converted into open grassland. Conversion in this case was not seen as an explicit strategy for expanding agricultural cultivation. Rather, it has been the result of more intensive land use, particularly the increased pressure from grazing and fodder collection. The average stocking rate for *Phalabang*, estimated in 1985, was 3.7

livestock units (LSU) ha^{-1}, considerably more than the recommended carrying capacity of 0.5LSU ha^{-1} (Wyatt-Smith ,1982).

Current Changes in the Farming Systems of the Mid-hills

The pressures of increasing population, reduced landholding size, declining returns to labour and the out-migration outlined above, do not lead inevitably to resource degradation. For example, the introduction of stall-feeding for animals in certain areas enables a reduction in numbers while maintaining or enhancing productivity, including the more efficient use of manure and labour (Campbell *et al.*, 1990). Increased fodder and fuel shortages provide the incentive for the increased cultivation of trees on farms, where enough land is available (Gilmour, 1988). Fast-growing leguminous trees, cultivated on terrace-risers, have enabled large increases in the productivity and numbers of animals kept in a few small localities (World Neighbours, 1991 *pers. com*).

The introduction of community forestry initiatives has entailed the handing-over of responsibility for management of village forest areas to Forest User Groups (FUGs). As yet, little information is available on the impact of this development on fodder resources and their utilisation. Anecdotal evidence suggests that these initiatives can have either positive or negative effects on fodder availability. Where, initially, FUGs have reduced access to forest products (often in order to “prove” their effective conservation of the resource), supplies of fodder and bedding traditionally collected from the forest have been reduced. In other areas, where the approved management plan has a built-in provision for accessing fodder and litter supplies, FUG members report improved access to these resources. The current project intends to provide information that will lead to a better understanding of the impact of community forestry (CF) initiatives in this area.

Livestock Production Systems in the Mid-hills

Livestock are a key component in the farming systems of the Mid-hills, and contribute to 16.7% of the agricultural gross domestic product of Nepal (Shrestha and Pradhan, 1995). Some 51% of cattle, 58% of buffalo, 44% of sheep, 57% of goats, 59% of pigs and 65% of poultry populations in Nepal are found in this agro-ecological zone. They provide draught power, income and dietary protein, and promote the effective cycling of nutrients through the system (Hopkins, 1983). Also, animals are kept as an investment, to provide cash for both planned events and as an insurance in times of need. The widespread reliance on manure as the major soil adjuvant in the hills means that livestock may still be kept for manure production when they are relatively unproductive in terms of milk, meat, or draught power.

The majority of livestock are raised by smallholders in sedentary management systems. Ruminants remain grazing under communal management systems during the day and return at night. Alternatively, they are stall-fed. Traditionally, large ruminants, chickens and pigs are kept but, more recently, Angora rabbits have been introduced. Pigs tend to be kept by hill ethnic groups of mongoloid origin. Small ruminants (goats and sheep) are associated mainly with the extensive transhumant systems. The movement of large numbers of small ruminants in the spring and summer from the upper Mid-hills into the mountains at higher altitudes is motivated by feed shortages. With the onset of winter, animals are moved down again to the Mid-hills for grazing and the utilisation of crop residues. During this period they may be camped in fields for manuring purposes. Overgrazing, particularly on slopes, is common and stocking intensities well in excess of optimum carrying capacities have led to an over-extraction of vegetative biomass from forests and open grazing areas. This has contributed to very high levels of soil erosion (>40 t/year) and an increase in noxious weeds. However, the transhumant system is in decline, and migratory flocks of small ruminants from Nepal that grazed traditionally on the rangelands of the Tibetan Plateau in China have been denied access since 1988.

Milk is produced for sale, largely by *Brahmin* and *Chetri* households. Likewise, marketed meat is produced to the greatest extent by hill tribal groups, including *Mugars*, *Gurungs*, *Rais* and *Limbus*. These divisions broadly coincide with the location of the former groups in the lower hills, where the intensity of crop production is greater and quantities of crop residues available as feeding are higher. The hill tribes now tend to be located in the Mid- to High-hills, where livestock production has relied traditionally on extensive grazing areas for feed. However, these divisions would appear to be blurring as the market for milk has extended further into the hills, through the introduction of stratified milk collection and distribution networks, and the reduction in transhumance and availability of extensive grazing lands.

Characteristics of Livestock Holdings in the Mid-hills

The livestock production systems of the Mid-hills of Nepal are characterised broadly by their multi-purpose and multi-species nature (Gatenby *et al.*, 1990), their close integration with cropping systems (Carson, 1992), and by high overall animal population densities in relation to the availability of land and other resources. Stocking rates range from 4-6 tropical livestock units (TLU)/ha and, generally, are higher than those found on similar farms in sub-Saharan Africa (Table 1). Usually, stocking rates are even higher in the transhumance systems of the higher altitudes over 2000 m.a.s.l (Alirol, 1979).

Table 1: *Observed mean livestock holding sizes on farms in the Mid-hills.*

Gurung *et al.* (1989)	4.8
Joshi and Panday (1991)	3.4
Thapa (1994)	5.8
Turton *et al.* (1995)	4.3
Sharma (1996)	2.9
Thorne and Gurung (unpublished data)	5.6
For crop-livestock systems in sub-Saharan Africa (Jahnke, 1982)	3.4

* conversion factors used are, buffalo - 1; cattle - 0.7; sheep, goats, pigs - 0.1

Tropical livestock unit (TLU) = 250kg liveweight.

Table 2 summarises the main species of livestock that may be encountered on farms in the Mid-hills and their principal contributions to the system as a whole and directly or indirectly to household livelihoods.

Table 2: *Species and the roles of livestock - in order of importance based on numbers of farmer responses - on farms in the eastern Mid-hills (adapted from Gatenby et al., 1990).*

Livestock Species	Major role	Minor role
Buffalo	Milk Manure Sales Curd Meat	Skin Horns Hobby
Cattle	Work Manure Milk Ghee Curd Sales	Hobby Dung for plaster
Sheep	Meat Wool Manure	Sales
Goat	Meat Manure Sales	Hobby Milk Religious purposes
Pig	Meat Manure Sales	Bristles Religious purposes
Chicken	Meat Eggs	Sales Manure Religious purposes Hobby

This table clearly illustrates the importance of those functions (manure and draught animal power) that integrate animals and crops, in addition to the ability to generate livestock products such as meat and milk. Indeed, amongst the 275 respondent farmers from whom the information was derived, more importance would appear to be attached to the contribution of cattle to manure production rather than milk. Sales are important for all species, particularly as a response to extreme hardship as described by Nabarro *et al.* (1989).

Nevertheless, for planning purposes, the relative importance of different species and classes of livestock can be difficult to disentangle, as this may be affected by the circumstances of the individual farmer. Survey data of Gatenby *et al.* (1990) indicate the extent to which the relative benefits derived from these uses vary amongst farmers and types of livestock. For example, between the five ethnic groupings, ranking of the relative contributions of different livestock species to income generation differed markedly (Table 3). Furthermore, information derived from a PRA study (Thorne, 1993) indicates the extent to which, from the point of view of the individual farmer, all species possess a number of positive and negative attributes (Table 4).

Table 3: *The effect of ethnic group on the rank scores of farmers for the capacity of different livestock species to generate income (numbers in bold are the species ranked highest by each ethnic group).*

	Chetri / Brahmin	Newar	Hill ethnic groups Gurung	Others *	Occupational castes ^
Buffalo	**240**	28	**20**	123	0
Cattle	162	14	14	85	57
Sheep	32	6	9	34	0
Goat	183	**36**	4	91	47
Pig	27	3	0	**179**	**62**
Rabbit	2	0	0	3	0
Duck	0	0	0	0	0
Chicken	49	10	4	33	12
Pigeon	2	0	2	0	0
Bees	0	0	0	2	0

* *Rai*, *Limbu*, *Magar*, *Sherpa*, *Tamang*

^ *Bhujel* (servant), *Damai* (tailor), *Kami* (blacksmith), *Kumal* (porter), *Sarki* (cobbler)

Clearly, livestock holding structures reflect a compromise position taken by the farmer in order to optimise the complex trade-offs between these production objectives and constraints.

It would appear to be possible to identify some systematic sources of variation in the sizes and structures of livestock holdings. Thorne *et al.* (1998a) reported that, in the Eastern Hills, mean holding sizes on *Chetri/Brahmin* farms were almost 25% larger in terms of the metabolic bodyweight of the animals kept than on *Rai/Limbu* farms ($BW^{0.75}$ = 263.7kg *vs* $BW^{0.75}$ = 213.5kg; SE_M = 24.1). This difference was also observed in survey of 1341 farmers in the region by Gurung *et al.* (1989) and appeared to be related, in part at least, to a difference in the sizes of the land-holdings of the two ethnic groups. Thorne and Gurung (unpublished data) found that the average size of *Rai/Limbu* land-holdings (35 *ropani*; one *ropani* is = 0.05 ha), was significantly smaller ($P < 0.05$, mean SE_M = 4.3) than that of *Chetri/Brahmin* holdings (50 *ropani*). The same data-set also suggested differences in land-holding types; *Rai/Limbu* farmers having a smaller proportion of the irrigated *khet* land on which rice (and rice straw) is produced than *Chetri/Brahmin* farmers. These differences may be expected to influence the quantity and availability of on-farm feed resources, particularly those of crop residues. Available information suggests that other factors may also be significant in determining holding size. Private ownership of and common-property access to other resources such as forests for fodder collection is probably not evenly distributed between the two ethnic groups (Campbell *et al.*, 1990). Differences in the availability of labour for feeding and general care of animals may also affect the size of holding that can be managed effectively.

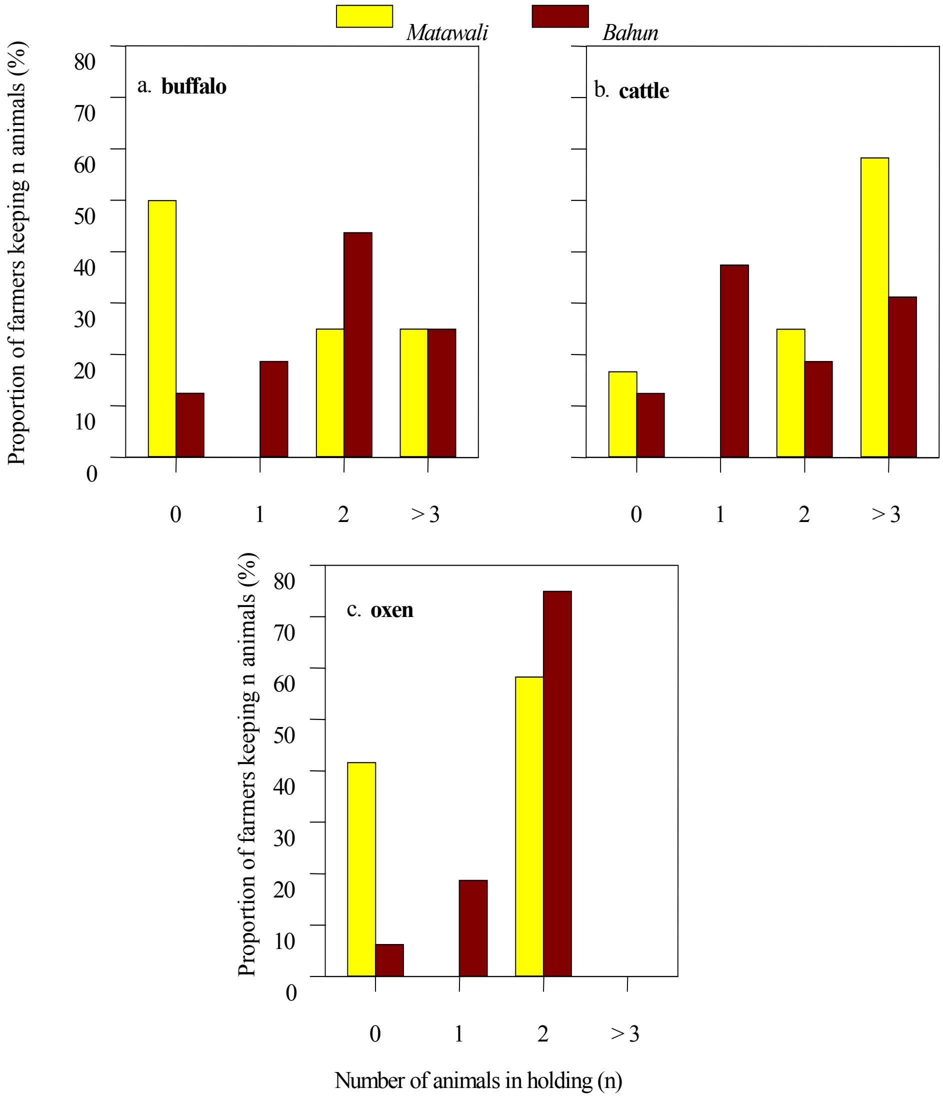
Table 4: *Perceptions of farmers of the positive and negative attributes of their livestock (Thorne, 1993).*

Livestock Species	Positive Attributes	Negative Attributes
Buffalo	Milk production Cash income from milk Cash income from calves Can sell infertile animals for meat Most profitable species Highest manure output	Cannot graze steep and difficult land High fodder requirement Long wait for returns Serious loss if animal dies Problem marketing milk *
Female Cattle	Can graze more difficult land than buffalo Provide replacement oxen Lower feed requirement than buffalo Milk better for young children	Difficult to dispose of older animals
Oxen	Necessary for draught power Avoids having to hire	Difficult to dispose of older animals
Goat	Graze anywhere Eat a wider range of feeds Produce high quality manure Low feed requirements Cash income from kids Most profitable species Gives quick return Provides worthwhile lump sum when sold Easy to market Less risk than large ruminants Less production loss during feed shortages No religious prohibitions	Susceptible to disease Require grazing area for best profitability High kid mortality Destructive if not confined
Pig	Fulfils religious obligations Produces meat Provides frequent cash return Better return per breeding animal per year than goat	Cannot be grazed Cannot sell piglets ^ Many religious restrictions Consumes a lot of feed Has to be fed concentrate
Poultry	Cash income Low feed requirements Gives quick return Best quality manure Can be sacrificed when a guest visits Better return per breeding animal per year than goat	Susceptible to predation Susceptible to disease Low manure output Damage crops

* In areas where there is no organised milk collection
^ as a result of a religious prohibition which applies only to certain rai / limbu sub castes

Thorne *et al.* (1998a) also reported significant differences in the structures of the livestock holdings kept by *Chetri/Brahmin* and *Rai/Limbu* farmers in the Eastern hills (Figure 2). *Rai/Limbu* farmers kept more cattle than *Chetri/Brahmin* farmers ($P < 0.01$) whilst *Chetri/Brahmin* farmers kept more buffalo ($P < 0.05$) and oxen ($P < 0.05$) in their holdings. Moreover, the ownership of buffalo amongst *Rai/Limbu* farmers appeared to be concentrated at two of the four sites included in the study. No significant differences were observed between farmers of different ethnic groups in the numbers of goats kept or in the ownership of improved crossbred cattle or buffalo.

Figure 2: *The effects of ethnic groups on structures of large ruminant holdings (from Thorne et al., 1994).*



Buffalo are valued greatly in the eastern Mid-hills because of the relatively high yields and quality of their milk, and for their manure for compost making. However, they are also more expensive to purchase and require more feed than cattle. For resource-poor farmers, substituting cattle for buffalo might allow production of milk and manure at a lower level of risk. Oxen are generally considered by farmers to be unproductive outside working periods, except for manure. Whilst reducing numbers of oxen may present problems in meeting work schedules, it may be an attractive option where holding sizes are seriously constrained by resource availability. Interviews with farmers (belonging to both ethnic groups) indicated that this strategy was considered actively by many (Thorne, 1993).

Livestock Products

Milk

In the Mid-hills milk production is estimated at 512,000 t, 58% of the total milk production of the country (Shrestha and Pradhan, 1995). Some 73% of the milk comes from the buffalo and the remainder from cattle. Milk is valued, in the first instance, for consumption within the family. Some farmers believe that cow milk is more suitable for young infants as it is less rich and, therefore, less likely to cause digestive upsets (Thorne, 1993). However, in general, buffalo milk is preferred because its butterfat content (c. 8%) is higher than that of the cows (c. 4%). However, Gatenby *et al.* (1990) report that prices for milk from buffalo and cows are the same in local markets, although there may be a premium paid for buffalo milk where this enters the wider marketing chain. Dilution of buffalo milk with water may also mean that, for the same daily yield, buffalo milk is more valuable to the farmer than that of the cow. Gatenby *et al.* (1990) also observed a systematic reduction of around Rs 0.18 / litre in milk prices with distance (in hours walking time) from markets. In some areas this relationship may be fading with the implementation of more organised milk collection and marketing networks.

Farmers who sell milk through local collection centres would appear to be foremost in the uptake of improved animals (crossbred Murrah buffalo and Jersey cattle), although such observations may be confounded with ethnicity issues (Gurung *et al.*, 1989). Milk marketed through the centres attracts a premium for butterfat content, so buffalo are likely to be the preferred species whenever animals are to be kept for milk sales. At 1993 prices, buffalo milk was selling for around Rs10/litre whilst the purchase price of a Murrah crossbred female was around Rs15,000. Therefore, an animal averaging 3.0 litres/day might be expected to return more than Rs16,000 over an 18-month lactation period, easily covering the purchase price of the improved animal from milk sales alone. However, some farmers still appear to be wary of the relatively high investment and the time taken to realise a return. Furthermore, buffalo are probably the most demanding species kept in terms of feed supplies, as their large body size demands a relatively high maintenance requirement and inhibits grazing access to steeper marginal land.

For farmers without access to milk collection centres, options for marketing surpluses are limited to local sales to teashops and the production of *ghee*. The former accounts for a very small quantity of milk in most areas whilst the latter involves the use of labour for *ghee* making, and is regarded as much less profitable than the marketing of fresh milk. The use of expensive crossbred animals is much less common in such areas.

Lactating animals are prioritised when scarce feeds are allocated. This applies to all species (including goats), and not just those which will produce surpluses for human consumption or sale. Strategies adopted include the feeding of protein-rich concentrates and the targeting of tree fodder species such as *Dudhilo* (*Ficus nemoralis*), which are said to promote milk production during the dry season (Thapa *et al.*, 1997).

Milk yields on farms in the Mid-hills are typically low (Table 5). The genetic potential of both crossbred and local animals ought to offer considerable scope for improving such low yields. However, the levels of investment of labour and capital are inadequate because of the multiple objectives of the livestock owners and the often poor access to markets.

Table 5: *Typical mean and peak milk yields (litres / day) of local and crossbred buffalo and cattle in the Mid-hills.*

Species	Genotype	Shrestha *et al.* (1988)		Thorne and Gurung (unpublished data)	
		mean	peak	mean	peak
Buffalo	Local	2.6		2.7	6.1
	Improved	3.3		3.1	6.8
Cattle	Local			1.3	5.1
	Improved			2.1	-

Meat

Some 54% of total meat production in Nepal is produced in the Mid-hills (Shrestha and Pradhan, 1995). The most important animals for meat are goats, pigs and poultry. However, some buffalo meat is available from older and unproductive animals. This may confer another advantage over cattle, as older and unproductive animals can be disposed of for meat, without religious restrictions, and generate further income.

Generally, goats are the most widely appreciated sources of meat. They are easy to rear as they would appear to be willing to consume a wider range of available feeds than other species and a relatively rapid return can be expected in comparison with the buffalo. Goat meat is the least proscribed meat for *Brahmin* and *Chetri* households, although the consumption of poultry meat has become more common amongst these ethnic groups in recent years. Gatenby *et al.* (1990) report definite and geographically- sustained price differences in meat from different species, ranging from Rs 20 / kg for buffalo to Rs 49 / kg for chicken. Part of this differential was attributed to differences in demand arising from religious or other cultural prohibitions. Pig meat, eaten by less than 50% of the population, sold for Rs 26 / kg whilst goat meat, consumed by almost all ethnic groups in the Mid-hills, sold for Rs 41 / kg.

Pigs are almost exclusively kept by *Rai*/*Limbu* and occupational castes. Some pigs may be slaughtered for a local *haat* bazaar and meat sold directly from the carcass by the owner. Others may be slaughtered to meet religious obligations, but this does not prevent consumption of the meat. Some *Rai* /*Limbu* people will also consume meat from fallen stock, but the market value of such meat is much lower (approximately 25% of that of a slaughtered animal).

Crop Livestock Interactions

In addition to generating the conventional livestock products described above, the role of animals as providers of manure, compost and draught power underpins the highly integrated nature of the farming systems of the Mid-hills. Arguably, the most important aspect of the livestock production systems of the area is the extent to which they interact with or are integrated with crop production. Figure 2 presents a schematic representation of the relative importance of the flow of resources between crops and livestock on a "typical" Mid-hills farm, and of flows onto and off the farm. Perhaps the most significant feature of the system is that it is, often, a relatively closed cycle. Off-take through consumption and, to a lesser extent, sales is balanced by importation from forest land and, where available, grazing. The direct utilisation of both on-farm and off-farm organic resources, via the green manure/mulch/compost pathway, is outweighed by channelling through the livestock component. In addition, livestock act as an important conduit for importing off-farm nutrients into the farming system in a form that allows their effective use as fertilisers.

Interfaces in Crop-Livestock Systems

In assessing the impact of livestock on the dynamics and performance of this type of system it is necessary to consider two major interfaces and their component processes:

- Livestock - Land
- Organic resources - Livestock

Livestock-Land

The livestock - land interface includes two quite distinct forms of interaction:

- the production of manure and compost;
- the provision of draught animal power;

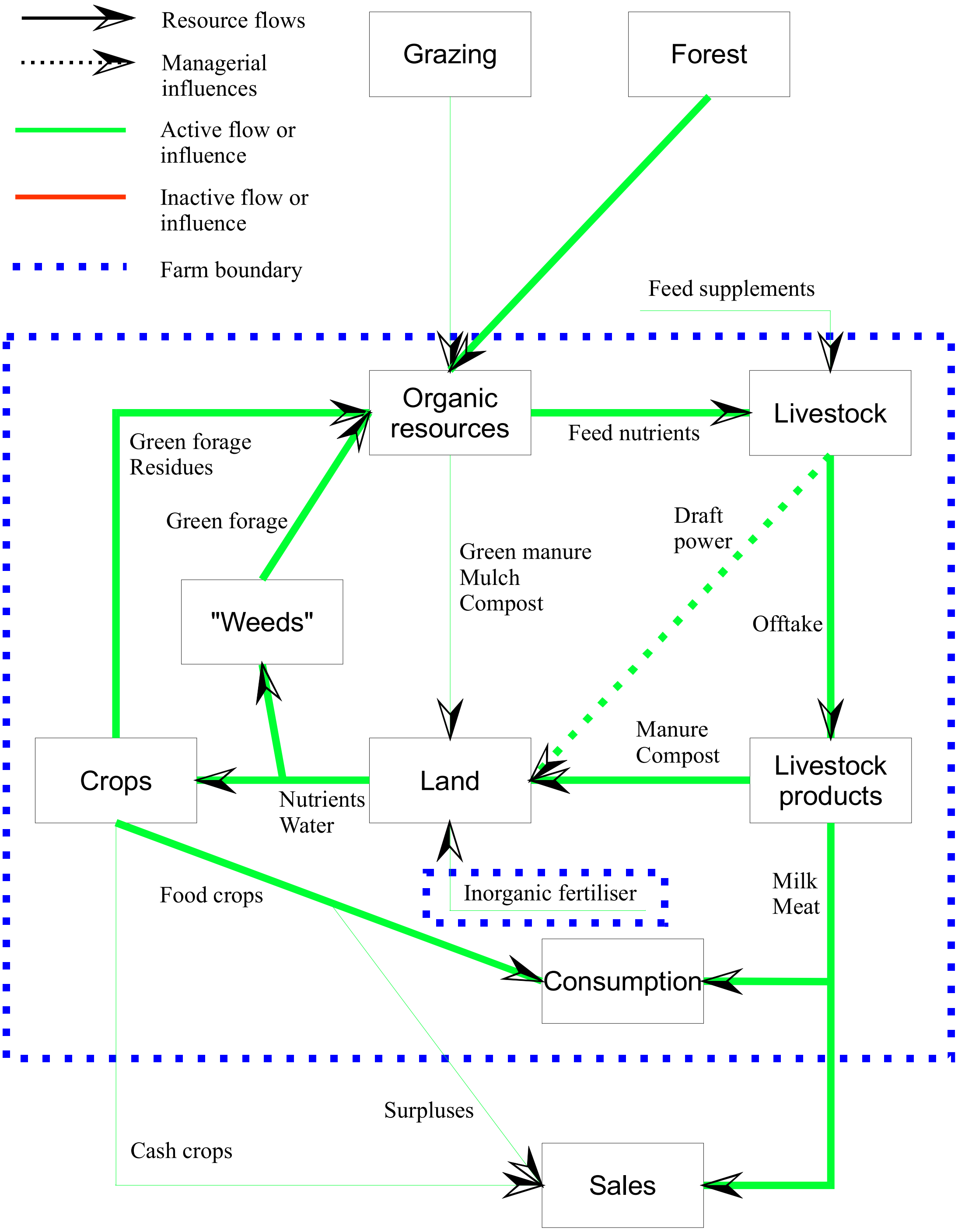
both of which may exert a considerable impact on the productivity of the cropping system.

Production and Utilisation of Manure-Compost

The pivotal role of livestock in the cycling of nutrients to crops, wherever the two are associated, has gained considerable ground in recent years as a topic of interest to both the research and development communities. An international conference in 1993, reported by Powell *et al.*(1995) and sponsored by the International Livestock Centre for Africa (ILCA), covered a wide range of issues relating to this aspect of the interface between livestock and soils.

A plausible case could be made for regarding manure as the most significant product of livestock in the Mid-hills. There can be little doubt that it is the need for manure to maintain cropping activities that integrates livestock so closely with cropping within the farming systems of the area. This is well appreciated by farmers and it is not uncommon to hear farmers state that, without livestock, there could be no crop production (Thorne, 1993).

Figure 1: *A schematic representation of crop-livestock interactions on small holdings in the Middle Hills of Nepal.*



The following anecdotes from a PRA conducted in the Koshi Hills by Thorne (1993) serves to illustrate the value placed on and effort expended in maintaining livestock for manure production by some farmers:

- One farmer interviewed referred to the severe dry season fodder shortage on his farm. Despite this, he kept two Murrah crossbred buffalo with high feed requirements as part of his livestock holding. For between four and five months of the year, these animals are fed almost entirely on purchased fodder. The farmer indicated that, overall, the cash cost of fodder is approximately equivalent to returns from milk sales at the local collection centre. The principal tangible benefit of keeping buffalo for this farmer was the manure produced. His buffalo acted as the route for importation of nutrients onto his cropland.
- A farmer belonging to one of the occupational castes, with a very limited land holding, kept one buffalo fed on purchased feed for around four months of the year. There was little market for milk in the area and reasons of caste status prevented him from accessing the limited market that did exist. He was able to sell a calf occasionally and the milk consumed assisted in keeping the family healthy. However, the respondent stated that the most important contribution of the buffalo was in maintaining the fertility of the poor, *bari* land that made up the majority of his holding. *Bari* land is not normally irrigated and supports maize and millet cultivation. However, occasionally, this land may be used for cash cropping (e.g. vegetable production).

Fallow grazing on *khet* (usually irrigated land on which rice is the main crop in the rotation) and *bari* land, or the coralling of animals in fields (sometimes referred to as *in situ* manuring), promotes the efficient return of nutrients via the animal to the soil. However, compost appears to be used preferentially on *bari* land, even if *khet* land is closer to the households where livestock are kept. This practice is consistent with observations of greater soil losses from *bari* land, resulting in a need to supply more nutrients from external sources to maintain crop productivity (Gurung and Neupane, 1991).

Inadequate supplies of manure and compost for maintaining soil fertility is a widespread problem; not only in limiting the productivity of land that is currently in production, but also preventing the development of marginal land for more intensive crop production. Rates of manure utilisation would appear to range from about 3-50 t/ha/year (Tuladhar, 1995; Sharma, 1996) supplying 10-140 kg N/year. Pilbeam *et al.* (1999) have estimated that a typical one-hectare farm, comprising mixed *khet* and *bari* land, might require about 130kg/N from manure annually.

The quality of manure from different livestock species can differ considerably as a result of differences in diet type, diet selection and digestive efficiency. Farmers in the Koshi hills appear to be aware of these differences (Thorne, 1993). Generally, sheep and goat manure was thought to be better in promoting crop growth than that of cattle and buffalo; some farmers maintaining that goat manure is as effective as urea. The highest quality manure was said to come from poultry, but quantities are too small on most farms for it to be used strategically. In the same study, some farmers expressed a view that dry materials are superior as composting material as they absorb a greater proportion of the urine. Campbell *et al.* (1990) received similar responses from farmers stating that pig manure was of the highest quality followed by goat manure. However, the quantities of buffalo and cattle manure available were much greater.

In some areas, a significant number of farmers have adopted the use of chemical fertilisers. It would appear that the impetus for the increased use of chemical fertilisers has come from a reduction in the availability of compost, and the need to increase yield per unit area from land holdings of decreasing size. However, it is clear that farmers do not regard chemical fertilisers and compost as interchangeable. Some farmers have developed strategies for using the compost and chemical fertilisers in combination to optimise benefits over a greater proportion of their land holdings.

Interestingly, farmers do not necessarily regard the use of chemical fertilisers as resulting in a saving on labour (Thorne, 1993), as the soil compaction associated with their use makes land preparation more difficult. Thus, the labour saved over composting at application time is insufficient to compensate for an increase in the labour required for land preparation. None of the farmers interviewed expressed direct concern about longer-term deterioration in soil structure and fertility associated with the use of chemical fertilisers. However, their comments on compaction and the need to maintain inputs to retain the yield advantage would suggest that they are aware, at least indirectly, of such issues. More recent studies in the Khosi hills area report concerns of farmers over reduced land productivity following the long-term use of urea fertiliser (Springate-Baginski *et al*., 1998).

Provision of Draught Animal Power

Draught animal power must be viewed in a somewhat different perspective to other elements of crop-livestock interactions. These generally represent resource flows from one system component to another. On the other hand, in the Mid-hills, draught animals are used as tools in the management of another system component-the soil-through tillage operations. However, their role in some situations in support of crop processing and marketing should not be underestimated. The workloads of oxen vary considerably, depending on the cropping pattern adopted on the farm, and fodder requirements vary accordingly.

Oxen play an essential role in the farming systems of the Mid-hills, as they are the only source of draught power for land preparation. Nevertheless, farmer perceptions of draught animals in mixed farming systems tend to be rather ambiguous. Access to draught animals is viewed as essential at times of the year when land preparation operations must be carried out. At other times, their feeding and general care may be viewed as a largely unproductive chore. Thus, draught animals may be managed on a basis of adequacy, with little scope for major increases in productivity through improved feeding or management. Some farmers, regarding them as useful only during certain parts of the year, prefer to hire them (Thorne, 1993). However, competition for available animals with other farmers often prevent the completion of essential tasks at optimum times. At a cost (1993 prices) of approximately Rs 45/day for the hire of a pair of oxen (similar to the average daily rate for unskilled human labour), a farmer adopting this strategy would have to be firmly rooted in the cash economy to make it viable. Gurung *et al.* (1989) reported that 85% of farmers surveyed over a wide area of the Eastern hills kept oxen. However, there may be considerable local variation in the extent of ownership of draught animals. In one village in the east, studied by Thapa *et al.* (1990), less than 50% of households owned any cattle at all.

Whatever the strategy adopted by individual farmers to furnish their draught power requirements, animals are indispensible. Nevertheless, they consume and compete for farm resources and their impact on the management of the system cannot be ignored.

Organic resources-Livestock

The interface between organic resources (both on-farm and off-farm origin) and livestock largely represents the supply of nutrients and energy in feed. Some brief, general observations on the nature of this interface are made here. However, as this topic forms the main focus of the review, it is discussed in greater detail in the following section. Some organic matter may also be used as bedding for animals, although this is associated usually with the effective trapping of nutrients in faeces and urine and is, therefore, more properly associated with the livestock-land interface.

The management of nutritional inputs at the organic resources-livestock interface may be achieved in two distinct ways:

- indirect management in a grazing or browsing situation;
- direct management of feed offered to livestock kept in confinement.

The management of grazing usually leaves animals to exercise a considerable degree of self-determination in what they actually consume. The length of access time and the area in which the animals are allowed to roam may be controlled by the herder. The estimation of quantitative intake and the mix of species consumed in a grazing situation is a topic that has occupied ecologists for many years. Therefore, in a generalised assessment of the availability and utilisation of feed resources, it may be difficult to estimate with even a reasonable degree of accuracy the contribution made by grazing.

Stall-feeding is common in the mixed farming systems of the Mid-hills. It allows farmers to exert a greater degree of control over the valuable manure outputs of their animals and also reduces the possibility of damage to crops caused by free-ranging livestock. The data of Thapa *et al.* (1990) suggest that the former is one of the major reasons for the adoption of stall feeding, although the increased opportunities for children (formerly employed in herding) to attend school was also considered to be important. However, complete stall-feeding is probably relatively rare, as the extra labour required for the collection of feed and bedding is not always available. Furthermore, where communal grazing areas are available, a failure to use them may represent a waste of resources. Thus, livestock kept in confinement will often be grazed as well, usually at a particular time of the year, when seasonal factors make this the most desirable management option.

Forage Resources and their Development

In the Mid-hills, some 50% of the total feed requirement comes from the farm, with the balance from stubble, forests, terrace-risers and bunds. Feed shortages have been identified widely as a major technical constraint to improved productivity of livestock kept under smallholder conditions in developing countries, and Nepal is no exception. Inadequate feed supply and poor nutrition during the dry winter season (mid-January to mid-May) are major constraints to increasing animal production. For example, in buffalo, there is a loss of about 25% in total milk production in each lactation due to inadequate feeding. There is a huge gap between potential and actual production. It has also been recognised that the nature and severity of these shortages may be affected by a range of factors that operate in different farming systems (e.g. ILCA, 1987). Despite this widespread perception, there have been few attempts to identify the principal sources of variation in the supply and utilisation of feed resources *at the farm level* and to quantify their effects. Without information at this level of detail, effective planning of research and targeting of extension recommendations for assisting smallholder farmers to optimise supplies of nutrients to their animals must be compromised.

In Nepal, forage resources and attempts to develop their more efficient and productive use would appear to constitute a particularly pressing area for research and development activities for the following reasons:

- The pre-eminence of feed shortages, amongst other resource constraints, has been confirmed by macro-level studies (e.g. Schreier *et al.*, 1991). Of 75 administrative districts in the country, 50 were found to be <80% sufficient in supplies of livestock feed. Whilst the country was found to produce a 25% surplus in food for its human population, a 40% deficit in animal feed was observed. Shrestha and Pradhan (1995) quote values for livestock dry matter requirements as 7,295,000 t and dry matter production as 4,337,000 t. In the Mid-hills, the feed deficit exists for 3-6 months.

- The terraced land of the Mid-hills must support very high human population densities. These have required the intensification of production from a system in which livestock are tightly integrated (Wyatt-Smith, 1982; Hopkins, 1983). Surplus biomass from cropping enterprises forms a significant proportion of available feeds. However, farmers also perceive that agricultural production would not be feasible without livestock to provide manure and draught power (Thorne, 1993). Typically, this important role is reflected in the high livestock population densities that are observed, in spite of the practical difficulties associated with keeping livestock on hillsides.

- The farming systems of the Mid-hills have operated for centuries and are developed to deal with the difficulties of farming intensively in a fragile ecosystem. As a result, farmers possess detailed systems of technical knowledge (Chand *et al.*, 1990) that support their decision making. These encompass information on the factors that affect feed quality and approaches to planning optimum feeding strategies, as described by Rusten and Gold (1991) and Thapa *et al.* (1997) for tree fodder. The detailed study of feed resource utilisation within this system can provides a useful overview of the extent to which relatively sophisticated smallholder farmers are equipped to manage feeding strategies, and where research results might supplement their existing capabilities.

- The study system is thought of as being in a state of flux, as land holdings fragment with increasing human population pressures and environmental degradation reduces the extent of arable areas. Farmers have developed strategies for coping with the effects of these changes. For example, Carter and Gilmour (1989) have described significant increases in the planting of trees on cropland for the production of fodder and fuelwood, as areas of common property forest land have been reduced. However, in relation to feed resources, Schreier *et al.* (1991) predicted that, by the year 2000, sufficiency will have been reduced from 43% to 26%.

Thus, what is currently required of research is the provision of focused information that will assist in developing strategies to counter the effects of these changes. The key requirement is for a supply of quality feed throughout the year. A lean period exists from October to March, when the most severe shortages are apparent. The feed balance situation in Nepal reveals the largest deficits to occur in concentrate feed and green fodder, 67 and 54 %, respectively (Pande, 1997). The same author also notes that supplementing straw feed with abundant use of concentrate rations has increased the cost of milk production. Severe deficits of green fodder also adversely affect communal forests and grasslands, as greater pressure is put upon them to fill the gaps.

Methodological Issues in Characterising Feed Resources

Some Problems

Any study of the utilisation of feed resources runs into two fundamental philosophical problems:

- How to define availability. The only useful definition of availability focuses on the point of delivery i.e. in the mouth of the animal. Thus, whilst the standing biomass of potential feed may represent an upper limit on availability, many other factors may combine to reduce the effective availability. These could include physical or social constraints upon accessibility, competition with other users, toxic factors requiring pre-processing, or availability of other resources such as labour that facilitate livestock feeding. This issue clearly has a basic impact on the selection of appropriate strategies for improving availability. Promoting more widespread planting of fodder crops and trees will have no impact if the limiting constraint is labour for feed collection and handling.

- How to define demand. Pandey (1982a) has estimated that around two tonnes of forage dry matter per TLU is needed by livestock in the Mid-hills and that, relative to this, most animals are underfed by about 20%. However, demand for feed is essentially a western concept derived from a position of plenty. Nutritional requirements are specified to maximise production, as this generally coincides with economic optimisation. This is not an appropriate paradigm for ***any*** smallholder mixed farming system as feed supplies will ***never*** be adequate to support maximum production year-round and, even if they were, such a strategy is unlikely to represent an economic optimum. In such systems there is a need to define a "basic demand" for feed that is determined by the level of production (or avoidance of death) at which the farmer deems it is still worth keeping animals. Having done this, it is then necessary for the farmer to plan the use of the "available" feeds to deliver the most appropriate production level that falls between the two extremes. The situation is further complicated by multiple objectives relating to the productive outputs of individual animals and the need to balance the feeding of different types of animal within the holding.

At present, there appear to be no satisfactory systematic approaches to either of these difficulties. For example, a farmer is unlikely to invest in improving the availability of feed resources unless the perceived marginal benefit associated with that investment is attractive. In order to assess whether or not this is the case, the researcher or planner needs a broad knowledge of the multiple objectives against which the farmer will evaluate these benefits.

Assessment of Quantity

A bottom-up approach to development-focused research requires the identification of researchable constraints under current conditions, followed by the formulation and testing of single or integrated component interventions to alleviate these. This necessitates some kind of diagnostic phase for both constraint identification, and the establishment of a baseline upon which the proposed interventions may operate. In the case of research directed at the development of feed resources, the diagnostic phase will usually require some kind of assessment of:

- the types of feed available;
- when, where, why and for whom these are inadequate for meeting the livestock production-related objectives of the farmer.

Currently, methodological approaches to generating this kind of information are a matter for some debate, but fall into to main categories:

- *Quantitative, longitudinal monitoring based on serial observations.* The most obvious way of assessing fodder adequacy is to generate an estimate of the quantities available in the target system and the levels of production associated with them. Longitudinal monitoring involves the recording of relevant data during a series of visits. These might include the types and quantities of feeds collected, offered and refused along with associated estimates of livestock performance indicators such as body weight changes, milk yields, reproductive events and mortality. In addition, various socio-economic variables may be recorded such as sources of labour inputs, returns from cash sales or the factors that underpin decision-making. Clearly, this type of study requires high inputs of time and, to generate relevant information under seasonal conditions, must be carried out for at least a whole year. Further difficulties may be encountered in the handling and interpretation of the large, heterogeneous data-sets generated (Thorne *et al.,* 1998a). A further possible criticism is that of Roeleveld (1996), who cautions against the assumption that quantitative measurement of a constraint will automatically reveal causes and possible solutions. However, a major potential benefit is that the data generated are detailed and in a form that should be understood easily by any natural scientists involved in planning interventions.
- *Qualitative information derived from a single or repeated PRA.* In order to reduce the commitment of resources required by long-term quantitative monitoring, the use of PRA tools to generate the information required has been mooted (Romney *et al.*, 1998). The problem with using a single visit to gather these data is that the feed shortage period that may be expected six months after the visit date is likely

to seem less important to the farmer than the helminth outbreak currently being experienced (Msangi, Bryant, Dijkman and Thorne, unpublished data). This can result in distorted perceptions by enumerators that are likely to be fatal to effective constraint identification. A possible solution to this problem is to undertake repeated visits at different times of the year. However, this may generate as many, if not more, problems in data interpretation.

A hybrid approach should be possible, and is most likely to provide the kind of diagnostic information required. However, it is still not clear from past experiences of this type of work which aspects of fodder supply require quantification to allow the identification of constraints, and which can be assessed adequately using PRA.

Assessment of Quality

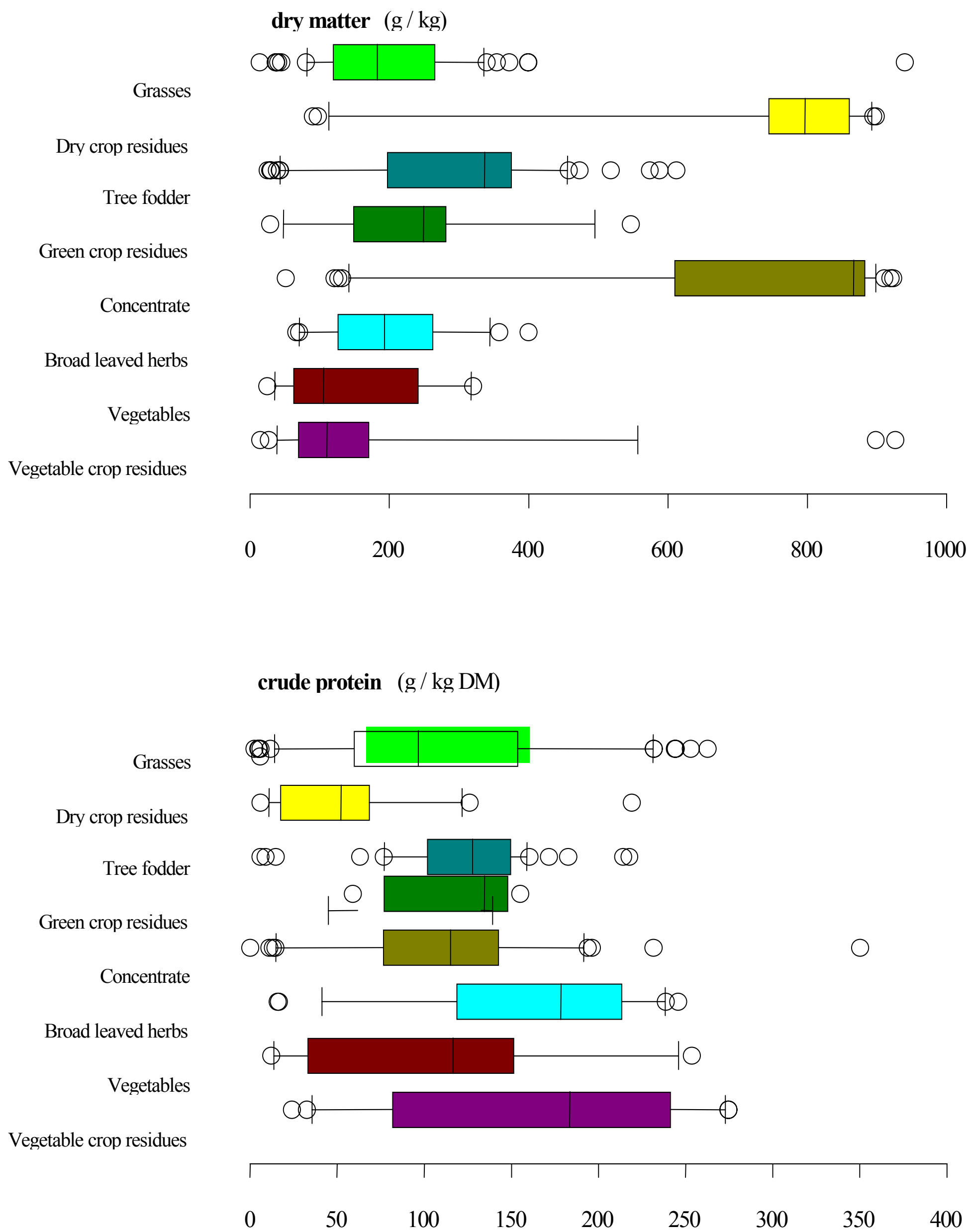
The principal problem in assessing the quality of feed resources is defining the term for the set of circumstances in which farmers are operating. Laboratory techniques for assessing the nutritive value of feeds assume a particular mix of objectives. Thus, if a feed is found to contain high levels of protein it is assumed to be of good quality. Conversely, if it contains high levels of cyanide, its nutritive value would be regarded as compromised to some extent. Recent research, comparing indigenous and laboratory-derived knowledge of the quality of Nepalese tree fodder, has provided a graphic illustration of the problems of unquestioningly accepting such assumptions. Nepalese farmers possess a sophisticated indigenous knowledge system that describes the nutritive value of tree fodder, and is used actively to formulate feeding strategies that will allow production objectives to be met. Thapa *et al*. (1997) examined, in detail, two local criteria for describing the nutritive value of tree fodder; *posilopan* and *obanopan*. *Posilo* fodder is said to promote milk and butterfat production in lactating animals, rapid liveweight gain and animal health. *Obano* fodder, also valued by farmers, is said to "fill the animal", be highly palatable and be eaten voraciously. The two classification systems are applied consistently amongst farmers and are demonstrably independent of each other (Walker *et al*., 1998).

It would appear that, in times of feed shortage, ensuring adequate gut fill may be the primary objective applied to feed planning so that behavioural problems with hungry stalled or working animals are avoided. Perhaps not surprisingly, a group of nutritionists presented with laboratory profiles for the tree fodder used in the study and asked to rank them for their value as dry season supplements did so in reverse order to the participating farmers (Thorne *et al*., 1998b). These findings clearly illustrate the importance of considering the objectives of farmers when planning research and making recommendations based upon this. Furthermore, they would suggest that a more integrated approach to intervention planning, based on combinations of indigenous and biological information, may have considerable utility.

A further difficulty in characterising the quality of feed resources can arise from the inherent variability in their chemical and physical composition.

The mean dry matter (DM) and crude protein (CP) contents of eight types of feed monitored in use over a 15-month period on farms in the Eastern hills and variability within each category are summarised in Figure 3.

Figure 3: *Variation in chemical compositions of a range of feed types used on farms in the eastern hills (Thorne, 1994)*



Mean dry matter contents ranged from 148g/kg for vegetables to 717g/kg in concentrates. Mean crude protein contents were lowest in dry crop residues (73g/kg DM) and highest in vegetable crop residues (164 g/kg DM). However, the variability within some feed categories (DM–concentrates; CP-vegetable crop residues, vegetables, grasses) was almost as large as the variability across all categories. Furthermore, this variation was not distributed randomly and could, depending on the category of feed under consideration, be explained partially by effects of site, ethnic group and season or their interactions.

The Key Feed Resources of the Mid-hills

The main feed resources in the Mid-hills are grazed fallow lands, crop residues (rice, wheat, maize, millet and barley) and fodder from forests. Strategies over the last 30 years to increase availability of feed have included the use of winter fodder crops on cultivated lands; the sowing of temperate and tropical perennial forage species and fodder trees on private uncultivated community lands; and silvipastoralism. This section of the review considers the nature of the key feed resources used on smallholdings in more detail. In the interests of clarity, feeds have been grouped as:

- grasses;
- crop residues;
- concentrates;
- herbaceous plants (including legumes);
- tree and shrub fodder;

A number of indicators of nutritive value are available in the literature (e.g. Ruiz and Ruiz, 1992). However, it is often not feasible to conduct a full analysis on all fodders used. A useful overview is provided by the DM, giving an estimate of the overall biomass availability and the CP, giving an indication of nitrogen (N) availability, which is important in this type of system as the nutrient that is first limiting on milk production. Crude fibre (CF) reflects the adequacy of the roughage component of the diet. However, this is unlikely to be a problem in the systems of the Mid-hills. These most significant characteristics of the five feed groups are summarised in Table 6.

For each group, the following issues are considered (where appropriate):

- *Sources, production systems and management* -the origins and necessary management inputs required to bring feed and animals into contact are described.
- *Productivity* - data from yield trials and estimates of level of production on-farms are summarised.
- *Nutritive value* - available information on the likely nutritive value indicated by laboratory analyses, animal response trials and indigenous knowledge are considered.
- *Potential for future development* - some current and recent activities aimed at improving the contribution of feeds belonging to each group are described and discussed.

In addition to published information, much of this section is based on inventories derived from a 15-month study conducted in the Koshi Hills during 1993-94 (Thorne *et al*., 1998a; Thorne *et al*., 1998c).

Table 6: *Significant characteristics of the five major feed groups used on smallholdings in the Mid-hills*.

	Role (basal or supplement)	Season of use	Purchased	Dry matter (g / kg)		Crude protein (g / kg DM)		Crude fibre (g / kg DM)	
				mean	standard deviation	mean	standard deviation	mean	standard deviation
Grass	Basal	Monsoon	rarely	267	144	140	74	230	114
Crop residues	Basal	Dry	sometimes	421	338	148	85	230	118
"Concentrate"	Supplement	Year round	mostly *	744	262	128	56	107	78
Herbaceous plants	Basal	Year round	rarely	206	98	169	58	173	62
Tree and shrub fodder	Supplement	Dry	sometimes	346	116	148	33	211	67

* Many concentrates may originate from crops grown on farms of users. However, some form of off-farm processing, that must be paid for, is often required before they can be used.

Grasses (including grazing)

Grasses and other green fodder from the terrace-risers form a major part of the diets of all ruminant livestock. These areas produce a significant amount of biomass. On average, terrace-risers make up around 25% of the land area in the Mid-hills (Malla, 1980) and up to 50% on the steeper hillsides occupied by poorer farmers. Grasses form the highest proportion of the total feed supplied over the year. In the study of Thorne *et al*. (1998a) more than 60% of the total fodder dry matter were grasses. A related and widely-used source of fodder for ruminants in the early wet season is the thinnings taken from the *bari* maize crop. Some farmers report that these could provide the green fodder requirements for their animals for up to 15 days (Thorne, 1993). The top of the maize plant (above the cob) may be fed directly at harvest time rather than stored for later use in the dry season.

Rangelands, 70% of which are in the western and mid-western regions, vary from sub-tropical grasslands at lower elevations to alpine meadows on the tops of ridges in the valleys of the Mid- and High-hills. Rangelands cover about 1.7 million ha, 13.4% of the total land area. Most of the rangelands (64%) are in the alpine region (LRMP, 1986) and, along with forests, are the main sources of grazing in the high mountains (Shrestha *et al.,* 1990). However, only 37% of the forage in rangelands are accessible to livestock, compared to 68% and 80%, respectively, in the forests and shrublands (ADB/ANZEC, 1993). Hill pastures are dominated by species of *Bothriocloa, Chrysopogon, Digitaria, Eragrostis, Heteropogon* and *Imperata*.

Both these resources appear to have become increasingly scarce in recent years. Areas of pasture have decreased due to the encroachment of cropland, and demands on available pastures have increased because of a rise in overall animal numbers. Loss of access to grazing on the Tibetan Plateau has forced transhumant flocks to travel further afield and to a lower altitude to meet their fodder requirements, thereby competing to a greater extent with the livestock of sedentary households. Over the whole period of settlement, cropland has encroached on forest land and, within the mid-altitude band, only steeper marginal land remains forested. Most of this is inaccessible to buffalo and some to cattle. Attempts to preserve this land under community forestry programmes may help to improve the fodder situation in the longer term. On such land, fodder may be cut and carried but this may be costly in terms of labour required. At the end of the dry season it is not uncommon for women to spend 3-5 hours collecting a *doko* of fodder from the forest, when this is the only green fodder available.

Cardamom planting has become widespread in some areas of the Mid-hills. This crop is valued highly by some farmers as a cash crop that is easy to grow. However, the possibility of poisoning means that farmers are reluctant to graze animals where the plant is widespread (Thorne, 1993). The result of these changes has been severe overgrazing of the pasture that remains, reducing grassland productivity by as much as 80% (Fleming, 1978).

The grazing of fallow *bari* and *khet* land is undertaken widely and has the added benefit of delivering nutrients in manure and urine directly to cropland. However, some farmers express reservations about the practice, as the amounts of fodder that the animals are able to consume may not justify the damage that they can cause to the terraces (Thorne, 1993).

Sources, Production Systems and Management

Early forage development work dates back to the 1950s, when improved temperate pasture species were introduced to the upper Mid-hills and mountains. In the lower Mid-hills, sub-tropical and tropical grasses were introduced. Winter in most parts of Nepal is dry and cold, so green fodder shortages are a serious problem. In the Mid-hills, fodder crops such as oats have been promoted.

Grass production on terrace-risers is traditionally of indigenous species that have arisen spontaneously. The timing of harvesting these grasses depends on their growth stage (timing of the rains), livestock requirement, alternative fodder sources and labour availability. Farmers frequently utilise off-farm fodder resources before their privately-owned reserves, conserving close supplies for later and for use during the busy planting seasons when labour is short. In some areas preferred indigenous species such as *Chrysopogon gryllus* are propagated and planted on terrace edges (Elliott, 1996). *Thysanolaena maxima* is another indigenous species cultivated on terrace-risers. The mature stems are used for broom making and the leaves produce good quality fodder.

Some introductions of exotic varieties have been used on terrace-risers. Small quantities of Napier grass (*Pennisetum purpureum*) and Setaria (*Setaria anceps*) have been used on farms in the Koshi hills and in the command areas of the Lumle Agricultural Research Station. There has been greater adoption of Napier grass and Napier grass hybrids (NB21 particularly) at lower altitudes. The cultivation of improved grasses has been stimulated by the increased demand for milk and milk-products.

Whilst the majority of households report some use of crop thinnings in animal diets, some households sow maize and millet more densely to provide additional green fodder. Crop thinnings only play a significant role in animal diets where farmers consider that there is adequate soil fertility and moisture to sow at a planting density considerably greater than that required for the mature crop.

Productivity

Performance of a large number of summer forage species has been evaluated at different locations for improved yield and availability over a longer period of time.

In a broad range of locations, Napier grass was found to produce almost double the amount of green matter (GM) (30.5t/ha) compared with native grasses (16.1t/ha) (LDF, 1988-93a & b, PTSMF,1988-93, AFSMF,1988/89). Within the Lumle command areas, Molasses grass (*Melinis minutiflora*) was identified as the most promising species to address the shortage of green fodder during the winter months (LAC, 1989). A comparison of six perennial summer forages at the same location found that Setaria was the most productive species (50.1 kg GM/ha/day) followed by Napier grass (31.2kg GM/ha/day) (LAC, 1987).

While comparisons of species in their yield per unit area are a useful initial indication of potential, farmers are interested in what can be achieved practically along a narrow, sloping terrace-riser. Comparing Napier grass with native grasses along terrace-risers, 8.5 and 4.6kg of green forage per square metre were obtained (PTSMF, 1988/89). In other areas, 8kg of green fodder could be harvested per running metre (LDF,1988-93a; AFSMF, 1988/89). In other trials, over a range of sites, Napier grass cut six times on average throughout the season yielded 13kg of green fodder per square metre. Length of harvest period varied considerably with site. Generally, Napier grass can be harvested from May to October, although in warm temperate regions harvesting can take place from March to December (FSR, 1990).

The cultivation of winter fodders on *bari* and *khet* land is gaining in popularity with some dairy farmers, in response to growing milk markets. Forage oats (*Avena sativa*) are grown from the Terai to the High-hills on land with sufficient moisture. Production from different cultivars of oats, grown at a range of locations, shows considerable variation from 19-26t/ha GM (cvs Swan and Kent within a rice-wheat cropping pattern at Baitadi) to 34-36t/ha GM (cvs Kent and 831 NC 19G3 at Khumaltar) (HLFP, 1996). Even higher green fodder yields have been achieved using oats in mixtures with legumes. However, these yields require high levels of fertility and moisture availability (Baidya, 1988; Bajracharya, 1986; Bhattarai, 1990). Significant increases in milk production, ranging from 0.3-0.45 l/day were achieved by feeding 6-8 kg of green oats daily to buffalo (Pandey *et al.,* 1990a).

The productivity of rangelands depends on many factors, and varies greatly within and between years from one area or region to another in the same agro-ecological zone. According to Pande (1994), productivity of native grasslands ranges from 0.5-1 t DM/ha in the steppes; 2-2.5t DM/ha in alpine, sub-alpine and temperate areas and 3-4 t DM/ha in tropical regions. Estimates of the carrying capacity of different rangelands have been made using these values, and are lower than current actual stocking rates (HLFDP, 1996). For example, a grassland dominated by *Heteropogon contortus, Eragrostis pilosula, Imperata cylindrica* and *Pogonatherum paniceum* in Bhumisthan VDC is estimated to have a carrying capacity of 0.31 LU/ha, whereas the current actual stocking rate is 4.08 LU/ha (Pariyar and Shrestha, 1992).

Nutritive Value

Grasses used by farmers in the Koshi Hills in the study of Thorne *et al*. (1998a), together with values for dry matter, crude protein and crude fibre are summarised in Table 7. There is considerable variation in these values. Furthermore, these are average values over a 15-month period and do not indicate seasonal variations. Thus, they are of limited value and it is difficult to compare these values with those in the literature from other regions.

Table 7: *Inventory of grasses, legumes and herbaceous plants fed to stalled animals on farms in the Koshi Hills (July 1993 - September 1994, n farms = 29).*

Feed name	Binomial classification	Dry matter (g / kg)	Crude protein (g / kg DM)	Crude fibre (g / kg DM)	Total dry matter recorded (kg)
Amliso	*Thysanolaena maxima*	231	179	272	19
Angare	*Term used fo r several species*	185	148	125	3
Arpi		400	88	280	1
Arthunge	*Heteropogon contortus*	307	70	322	56
Ashare	*Term used fo r several species*	939	54	146	97
Banso		265	78	288	1709
Banso (Chitre)		176	120	280	3
Banso (Dhoge)		177	278	422	12
Banso (Furke)		178	156		36
Banso (Ghode)		145	116	389	2
Banso (Hade)		291	67	288	84
Banso (Sim)		214	79		8
Bhutlo		400	88		27
Bilmate		354	251	157	4
Boatdhamero		400	88	280	2
Bukiphul		273	70	331	1
Damme jhar		200	116	267	1
Dhokre flower		100	404	108	3
Dubo	*Cynodon dactylon*	292	153	206	53
Gede ghas		400	88		6
Guyejhar		162	167	229	4
Ilame		117	247	141	141
Kane	*Floscopa scandens*	104	121	147	3
Kangio		290	112	124	7
Kans	*Utricularia bifida*	399	161	702	139
Kharuki	*Pogonatherum incans*	339	92	311	1725
Kode jhar	*Eleusine indica*	91	200	233	
Ladirame		400	88		7
Lurke		86	246	97	4
Lutke		400	88		2
Mahel		399	84	125	1
Mixed grass		400	88	280	3899
Muhune		400	88	280	1
Napier	*Pennisetum purpureum*	243	75	324	66
Naule		400	88		10
Panchpate		400	88		7
Phurke	*Arundineria falcata*	263	108	325	181
Pilmete		400	88		
Putli		211	125	238	13
Ratnaulo	*Bistorta amplexicatus*	94	199	156	73
Remai		90	217	165	75
Salimbo		307	97	321	1004
Sama	*Echinocloa cras-galli*	156	136	229	158
Siru	*Imperata sp.*	319	75	287	1253
Syawola					
Udase		117	247	141	107
Total					11008
Mean		278	134	250	256
Standard deviation		151	72	114	707

Potential for Future Development

Rangelands are under considerable threat, accentuated by the migration of livestock from alpine pastures in winter. If the trend of encroachment of land for agricultural terraces is not stopped, the stocking rate would reach 21 times the actual carrying capacity. Hopkins (1985) estimated that, in some areas of the Eastern hills, stocking rates are now close to 8.0LU/ha. The result will be progressive overgrazing, the loss of desirable species, weed invasion, an increase in bare ground and erosion.

The impact of cultivated grasses on green fodder quantity, availability and quality can be very significant, as shown by the previous data. However, much of the data comes from experimental studies on-station. Thorne (1993) reported farmers expressing particular interest in introduced cultivars that could provide green fodder in the dry season, and there are examples where improved pasture species have been used on-farm to increase livestock numbers and milk production (New Era, 1990). Nevertheless, to date, uptake of this new technology has not been widespread.

The introduction of forage crops such as oats into rotations has attracted interest amongst research workers, but there has been little adoption at farm level. While such crops have the potential for producing much needed green fodder during the dry season, they consume valuable resources of water and nutrients and are considered to be in competition with the following crop.

Crop Residues

Large ruminants are dependent on crop residues, particularly in the dry season. For example, >10kg/head/day of crop residues are fed to lactating buffalo in the dry season (Shrestha, 1992). Buffalo, particularly, are efficient converters of crop residues. About three million tonnes are produced annually in the Mid- and High-hills, and some 32% of the total feed supply in Nepal comes from this source (Shrestha, 1992). The major crop residues fed to livestock in the Mid-hills are rice straw (60%), maize stover (22%), wheat (14%) and millet/barley (4%). However, not all of the crop residues are used for animal feed. Other uses (30%) include bedding, roofing and compost (Dhaubhadel and Tiwari, 1992). Farmers in wetter areas state that rice straw is the best quality crop residue, as it is harvested during a drier period and maintains condition during storage (Thorne, 1993). Where this is the case, maize and millet stovers are used early in the dry season to avoid deterioration. In drier areas, farmers appear to prefer millet stover to rice straw, but it is unclear whether this is due to the availability or quality of the material.

Rice straw is sometimes purchased where there is a shortage and farmers have productive (usually milking) animals to maintain. Six years ago, this would have been at the relatively high cost of Rs3.50 for approximately 500g (Thorne, 1993). Some farmers arrange for feeding of their animals by another household during periods of feed shortages. This is on an exchange of manure for feed basis, but is unlikely to be practiced with lactating animals.

Crop residues of relatively minor importance are the haulms of legumes (soyabeans, cowpea, black gram, lentils) and potatoes, that may be grown as inter-crops with maize and millet. Quantities of these are relatively limited, but farmers regard their quality as superior to that of the cereal residues. Some farmers regard quantities as being too limited to warrant a strategic decision on their use, whilst others value these materials as a component of their concentrate mixtures. Discussions with farmers suggest that, although these residues are not fresh green fodder, their quality is treated as equivalent to this.

Sources, Production Systems and Management

Generally, rice is cultivated under irrigation and so production at the household level is limited by the area of *khet* land owned and cultivated. The amount of straw production will depend on the number of crops sown per year, which may range from one to three, and the varieties grown. Frequently, improved varieties have shorter straw length than indigenous varieties, but the higher recommended density of planting leads to similar amounts of straw being produced. Some farmers observe that quality of the straw of improved varieties is not as good as older varieties. Maize stover may be fed to cattle during the growing period of the crop , with leaves stripped from the stem and tops cut after tassling. Practically, this forms part of the green fodder component of the diet. Such practices are in response to green fodder and labour shortages, and the difficulty of maintaining quality in stored maize stover.

Productivity

The bulk of crop residue available for animal feed comes from the major grain crops, rice, maize, millet and wheat. The amount of residue produced per given area will depend on the type, density and variety of crop grown. While sowing density and germination percentage can influence crop density, under good management it is largely fertility and moisture levels that determine production level. Straw yield can be estimated from known grain yields using the crop's harvest index. Harvest index is the economic (grain) yield of a crop expressed as a decimal fraction of total above ground dry matter. This value differs between crop types and between different varieties of the same crop type (table 8a).

Table 8a Range of harvest indices for different species and in some cases varietal types.

Species	Type	Harvest Index
Triticum aestivum	Winter (semi-dawf)	
(wheat)	UK (high fertility conditions)	0.43-0.54
	Drier areas Australia, India (Lower yield potential)	0.3-
Hordeum vulgare	Winter	
(barley)	UK (high fertility conditions	0.43-0.57
	Drier areas Australia, India (Lower yield potential)	0.3-
Oryza sativa	Wetland	
(rice)	Philippines	0.55-0.62
	India	0.35-0.59
Zea mays	Hybrid Canada/ USA	0.42-0.57
(Maize)	Hybrid Nigeria	0.36-0.46
	Worldwide	0.35-0.60

(Adapted from Hay, 1995)

Modern selection processes and crop breeding have tended to produce varieties with higher harvest indices. With a greater proportion of dry matter in the grain, straw yields will only be maintained if total biomass production is also increased. Quality of the residue from modern varieties is also an issue because selection for stem strength and stiffness tends to lower nutritional value. Shorter, stiffer stems may be an advantage, however in preventing quality reduction that occurs in wet conditions, when a crop lodges sometime before harvest. This is a particular problem in paddy rice where losses of 50% of palatable straw from early lodging, is not uncommon.

Common trends within farming systems in the Mid-Hills have different influences on crop residue production. Intensification of the farming system through the introduction of an additional crop (such as winter wheat, or second/third crop paddy) will increase residue production per area, while reduction in soil productivity levels will tend to reduce straw yields.

Nutritive Value

Despite their importance as animal feed, crop residues are of low nutritive value. Unsupplemented straw will not maintain animal productivity. Straw only diets result in loss of body condition and milk yield (Shrestha, 1992). The availability of energy is restricted to <50%, due to the presence of lignin (Dhaubhadel and Tiwari, 1992). High contents of oxalic acid also occur. Accordingly, voluntary intake is low; 1.5% of body weight. Crop residues used during a 15-month period in the study of Thorne *et al*. (1998), together with their dry matter, crude protein and crude fibre contents are summarised in Table 8. As anticipated, the nutritive values of the different residues are generally low. The use of commercial-grade urea on rice straw has increased digestibility, voluntary intake by 30% and milk yield by 20% against conventional diets (Shrestha, 1992). In another study with lactating buffalo, treatments consisting of urea-sprayed straw, 5% mustard cake, 0.1% salt or chaffing and soaking in water were compared. The highest milk yields were recorded in the first two treatments.

Table 8: *Inventory of crop residues fed to stalled animals on farms in the Koshi Hills (July 1993 - September 1994, n farms = 29).*

Feed name	Dry matter (g / kg)	Crude protein (g / kg DM)	Crude fibre (g / kg DM)	Total dry matter recorded (kg)
Banana leaves	146	198	170	1
Banda kopi leaf	56	273	192	4
Bean hulls	898	78		115
Bean lahara	111	306		3
Bean lahara + Bean pod	519	218		8
Bean pod	926	130		8
Black gram haulm	898	141	177	26
Cauliflower leaf	296	213	124	9
Chana (Haulm)	40	204	196	
Chayote lahara	84	174	193	4
Chayote peel	110	185	167	2
Dangre mas ko kunauro	728	120	280	20
Gahu ko nal	785	33	351	188
Khoselta (Dry)	835	31	335	417
Khoselta (Green)	209	152	255	117
Lahara	128	123	63	6
Maize cob	750	21	365	39
Maize leaf	222	136	337	398
Maize stover (Dry)	838	52	312	1285
Maize stover (Green)	254	116	237	769
Millet straw (Dry)	837	52		1501
Millet straw (Dry) + Rice straw (Dry)	179	234	145	
Millet straw (Green)	249	64	275	784
Mustard haulm	894	26	519	27
Oat (Forage)	125	155		9
Pangra ko lahara	207	303	189	
Pea haulm	884	84	425	27
Pidalu leaf	60	82	152	1
Potato lahara	80	182	152	10
Pumpkin lahara	127	275	55	67
Radish leaf	110	250	128	5
Rayo leaf	84	258		4
Rice bran + Millet straw (Dry)	852	79	139	2
Rice straw (Dry)	756	83	222	2933
Rice straw (Dry) + Millet straw (Dry)	796	67	111	5
Rice straw (Ghaiya)	756	83	222	48
Rice straw (Green)	546	134	309	351
Sagh	110	250		1
Shuthini lahara	127	275		2
Soya bean haulm	907	34	494	78
Sugarcane leaf	290	59		4
Sweet potato lahara	118	232	59	21
Vegetable leaf waste	190	199		4
Total				9304
Mean	421	148	230	233
Standard deviation	338	85	118	557

Potential for Future Development

Crop residues are the main source of energy and protein in practical feeding systems for large ruminants, and this situation is unlikely to change in the foreseeable future. However, crop residues are of low nutritive value. Accordingly, there is still considerable potential for improving the utilisation of crop residues by smallholders. Pre-treatment of straw, to reduce wastage and improve nutritive value, can range from physical treatment to a carefully-controlled fermentation process involving biological or chemical treatment. Treatment of rice straw with urea is one method that has been commonly used. Trials have shown that, to reduce costs, urea can be replaced by urine (in a 1:1 solution of water) with no reduction in productivity of milking Jersey cows (Khanal, 1997). Wheat straw and maize stover may also be treated with urine to improve fodder quality. Although this technology has been tested extensively in experimental stations and promoted in South Asia generally, it has not been adopted widely at farm level. In a survey of 134 farmers in four Koshi Hills districts, quoted by Shrestha (1992), <1.0% used treated straw. The reasons for this included a lack of awareness of the technology, a shortage of manpower and a lack of availability of inputs (urea, plastic sheeting). Perhaps the best and most practical approach to improving the nutritive value of crop residues is supplementation with tree foliage and improved grasses and legumes. Shrestha (1992) quotes examples of the positive effects of tree foliage and cassava leaves on voluntary intake and body weight changes. The integration of oats and berseem in rice-fallow systems can increase fodder availability from arable land, and can be used as a supplement to untreated straw. An alternative approach is the use of dual-purpose cereal varieties that combine high grain yields with high production of biomass and increased nutritive value. In India, for example, studies on the genetic enhancement of nutritive value in cereals such as pearl millet and sorghum are being conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). From a review of the literature, Zerbini and Thomas (1999) have concluded that potential exists for selecting or breeding varieties with improved straw and stover nutritive value, without sacrificing grain yields. Variation in digestibility exists, and this is heritable.

Lack of availability of green fodder during the dry season is a key production constraint identified by a wide range of farmers. Ensiling of green materials, such as maize tops harvested at the end of August and early September, in a pit protected from the rain can conserve green fodder in a palatable form for 2-3 months (Khanal, 1997). The silage successfully replaced fresh green fodders as a component of buffalo diets, with no negative effect on milk production. In another trial, the addition of maize silage at a rate of 9.5 kg/day increased milk production in buffalo by 52%. However, another trial involving the ensilage of maize stover produced conflicting results (Dhaubhadel and Tiwari, 1992). The differences in the results between the two trials may have been due to differences in the quality of the silage and the small number of animals used. More controlled studies with larger numbers of animals are required for future studies.

Conservation by ensiling raises the question as to whether research should focus on trying to extend green fodder production into the dry season, or on maximising production during the wet season and conserving this for later use. Uptake of new methods of storage has been very limited. However, this is linked to the shortage of green materials to ensile. In theory, it is possible to increase fodder production during the wet season because of the good growing conditions.

"Concentrates"

The use of concentrates (*kundo*) varies with animal type and individual holding. Generally, lactating females, oxen (during work periods), fattening goats and pigs all receive some form of concentrate feed. Some concentrate compositions and feeding practices observed on farms in the Mid-hills are summarised in Table 9. Concentrates are based on the more nutrient-dense crop residues, green fodder and mustard cake but their composition varies depending on the type of animal fed. In the Koshi Hills, mustard cake is used only as an ingredient in concentrates fed to lactating animals (buffalo, cattle and goats). This suggests that the fact that the lactating animal is limited principally by dietary protein (supplied in a relatively concentrated form in mustard cake) and that the working/fattening animal is limited principally by energy has been appreciated intuitively, and a feed-allocation decision has been made accordingly. Cooking of concentrates is usually restricted to those that are to be fed to lactating animals. The method used involves boiling of all ingredients together for approximately 30 minutes.

Table 9: *Use of concentrate feeds on farms in the Koshi Hills (Thorne, 1993).*

Basic ingredients	Maize husk, rice bran	Maize husk, rice bran	Maize husk, rice bran	Maize flour, maize husks, maize bran, rice bran, *tongba* residue[1]
Green fodder	Soya bean haulm, cowpea haulm, pumpkin tops	Soya bean haulm, cowpea haulm, pumpkin tops		*dudhilo*[2], colocasia root & leaves
Mustard cake?	Yes	No (unless surplus)	No (unless surplus)	No
Others	Salt , *jwanu*[3]	Salt	Salt	
Cooked?	Yes	No	No	Only nettles
Specific feeding practices	May increase proportion during winter	Offered less than buffalo		Lactating sows are fed greater quantities more frequently

[1] - Fermented millet remaining after brewing (not available in *Chetri* / *Brahmin* households).

2-
Ficus nemoralis
Trachyspermum amni : said to promote milk yield in small quantities.

Sources, Production Systems and Management

Currently, few concentrates are fed to ruminants in the Mid-hills and, therefore, they do not make a major contribution to the feed supply. Following the extension of milk collection sites into the hills, farmers are adopting strategies to increase milk production. It is likely that the use and importance of concentrates will increase as the importance of income derived from milk sales increases.

Productivity

As a rough rule of thumb, approximately one third of the raw grain weight will be "lost" during the process of preparing grain for human consumption. Some of the by-products can be used in further products for human consumption, all are potential animal feeds.

For example, modern milling of rice consists of successive stages to remove the hulls, then the bran layer and finally polish the milled kernels, so as to produce a high proportion of whole kernels. This results in a milled rice recovery equal to about 65% or more of the original paddy by weight, consisting of 45-60% whole/three quarters kernels, 10-20% broken grains and about 18% rice bran (Litzenberger, 1974). Local types of rice mill used on rice for home consumption, dehull and polish the rice in one operation. These tend to produce a greater proportion of broken kernels and may waste some of the bran.

Nutritive Value

Concentrates used over a 15-month period in the study of Thorne *et al*. (1998a) and their dry matter, crude protein and crude fibre compositions are summarised in Table 10. It is clear that concentrates, by definition, are of high feeding value and are major sources of energy and protein.

Table 10: *Inventory of "concentrates" fed to stalled animals on farms in the Koshi Hills (July 1993 - September 1994, n farms = 29).*

Feed name	Dry matter (g / kg)	Crude protein (g / kg DM)	Crude fibre (g / kg DM)	Total dry matter recorded (kg)
Concentrate + Armale	431	116		1
Jandh ko chokra (brewing residue)	121	183	105	2
Kat (brewing residue)	127	194	77	6
Maize bran	876	91	59	181
Maize bran + Maize grain + Salt	866	107	46	15
Maize bran + Rice bran	765	99	230	73
Maize bran + Rice bran	871	99	168	83
Maize bran + Rice bran + Salt	774	95	220	4
Maize bran + Salt	881	87	57	43
Maize grain	886	133	37	262
Maize grain + Maize bran	881	112	48	52
Maize grain + Maize bran + Salt	590	120		10
Maize grain + Rice bran	838	100	153	40
Maize grain + Rice bran	876	119	157	42
Maize grain + Rice bran + Salt	881	115	151	20
Maize grain + Salt	891	127	35	13
Mash kumauro	871	99		1
Millet bran	876	91		5
Mustard cake	923	350	127	40
Mustard hulls	898	78		1
Oat (Dry)	860	109		10
Pea bokra	898	78		72
Philinge dhuto	521	176	162	4
Rice (Cooked)	180	72	2	1
Rice bran	866	106	277	308
Rice bran + Mustard cake + Maize grain	890	196		1
Rice bran + Mustard cake + Salt + Maize grain	919	147		
Rice bran + Salt	132	231	88	4
Rice bran + Salt	871	101		30
Wheat bran	892	107	7	1
Wheat grain	910	115	29	1
Total				1325
Mean	744	128	107	44
Standard deviation	262	56	78	76

Potential for Future Development

In Nepal, cereal grains are produced mainly for human consumption, so the supply of concentrates for livestock is very limited. The largest feed deficit (67%) occurs in concentrates (Pande, 1997). The use of fertiliser-grade urea as a supplement has shown positive effects on animal productivity. It is the cheapest and most easily-available source of protein to supplement cereal straws. However, this technology has not been adopted widely. In a survey of farmers in the Koshi Hills, approximately 50% of farmers said that they knew nothing of the technology, whilst 27% quoted a lack of extension as the main reasons for lack of adoption (Shrestha, 1992). Other reasons for lack of uptake of new technologies are given by Dhaubhadel and Tiwari (1992). As in other countries of South Asia, there is considerable potential to make more efficient use of locally-produced by-products. Significant quantities are wasted whilst other sources remain under-utilised. Any improvement in this situation will depend on the effectiveness of the extension services and NGOs in diffusing recommendations, as well as cost.

Herbaceous Plants (Including legumes)

Many herbaceous plants, such as *Banmara* (*Eupatorium adenophorum*), are regarded as noxious weeds resulting from overgrazing (Thapa, 1990). Nevertheless, they provide valuable year-round supplies of nutrients, particularly for goats. There is a perception amongst farmers that goats will accept a wider range of feeds than cattle or buffalo. Terrace-riser "weeds" such as *Titepati* (*Artemisia vulgaris*) are also used widely for goats. The potential for feeding *Banmara* to larger ruminants in the absence of other feeds might warrant investigation, although farmers suggest that the feed is unpalatable.

A variety of leguminous species have been introduced into Nepal, most notably vetches (from Australia) and species of *Trifolium* including white clover (India and other sources). Four types of vetch are used mainly for fodder, namely, *Vicia sativa*, *V. bengalensis* cv. Papany, *V. dasycarpa* cv. Nemoi and *Aeschynomene americana*. The highest dry matter yields are obtained with line sowing and fertiliser additions. Trials involving the use of 60kg N and P/ha and line sowing at 30cm distance produced on average, in 3-4 cuts, four times more green fodder than broadcasting (PTSMF, 1988/89). Shaftal clover (*T. resupinatum*) has shown promise in trials as a potential source of high quality green fodder and protein during the dry season (PTSMF, 1985/86). Again, productivity was greatest with the addition of fertiliser (60kg N and P/ha), irrigation and line sowing. Berseem (*T. alexandrinum*) is cultivated in the Terai and warm temperate regions of the Mid-hills (HLFFP, 1996). Phosphorus is one of the limiting factors in forage production for Berseem. Under irrigated lowland conditions on-farm, in a rice-fallow-rice cropping system, the optimum level of fertiliser was identified as 60:120:0 kg/ha NPK (FSR, 1989/90;FSR, 1991/92). An economic optimum level of 20:40:0 kg/ha NPK has been recommended in Pokhara (Pradhan and Silwal, 1989). As a relay crop, the recommendation in the Terai is to sow Berseem 4-6 weeks before harvesting the rice.

Tropical legumes have also been introduced into Nepal. Species such as *Cassia rotundifolia* cv Wynn, *Desmodium intortum* cv greenleaf, *D. uncinatum* cv silverleaf, *Neonotonia wightii* and *Stylosanthes guianensis* cv Graham have all produced significant yields of green fodder ranging from 3.8t/ha to 24.6t/ha in eight cuts (Neupane and Shrestha, 1991). At altitudes of below 1700m.a.s.l, fertilised stands of *Stylosanthes guianensis* cv. Cook have yielded as much as 33t green fodder/ha. However, levels of production in the dry season are dependent on moisture availability.

Sources, Production Systems and Management

Shrestha and Pradhan (1995) have highlighted the need for future research in the Mid-hills to focus on the integration of forage production with cropping. Food crop production will always be a priority in farming systems, but there is a need to increase on-farm forage resources to reduce the grazing pressure on the fragile hills and mountains.

Productivity

There is experimental evidence to show that the introduction of legumes can have a marked effect on productivity, particularly the yield of green fodder in the dry season when feed deficits occur.

Nutritive Value

Herbaceous plants used over a 15-month period in the study of Thorne *et al*. (1998a) and their dry matter, crude protein and crude fibre contents are summarised in Table 11. The inclusion of high quality tropical and temperate legumes will increase markedly the nutritive value of feed.

Table 11: *Inventory of herbaceous plants fed to stalled animals on farms in the Koshi Hills (July 1993 - September 1994, n farms = 29).*

Feed name	Binomial classification	Dry matter (g / kg)	Crude protein (g / kg DM)	Crude fibre (g / kg DM)	Total dry matter recorded (kg)
Abijalo	*Drymaria diandra*	151	198	160	5
Armale jhar	*Anagallis arvensis*	97	133		1
Banmara	*Euphatoria adenophorum*	127	186	153	214
Banzpate	*Rumex dentatus*	183	155	220	58
Buletro	*Butea minor*	266	212	243	73
Dhangero	*Woodfordia fruticosa*	357	66	115	14
Juwane jhar	*Fimbristylis miliacea*	231	173	205	7
Kali Lahara	*Marsdenia tinctoria*	189	125	186	1
Kamle	*Pilea symmeria*	131	206	121	66
Khorsane	*Pittosporum napaulense*	326	110	116	2
Kurkure	*Blumea lacera*	180	115	226	11
Kurro	*Bidens biternata*	224	261	76	179
Latte sag	*Amaranthus viridis*	141	301	68	8
Maleti	*Mazur pumilus*	400	70	127	30
Mothe	*Cyperus rotundus*	197	78	283	67
Phulkanda		251	222	100	3
Puruni Ko Lahara	*Cissus repens*	153	157	230	4
Salaya (Surke)		125	246	136	7
Sava	*Diplocyclos palmatus*	400	88		24
Sayapatri	*Tagetes erecta*	126	233	84	
Sisno	*Urtica dioca*	66	239	83	7
Titepati	*Artemisia vulagaris*	216	188	268	269
Unue	*Dryopteris fillix-mas*	198	184	233	21
Total					1067
Mean		208	170	164	51
Standard deviation		94	66	70	76

Potential for Future Development

There is significant potential for the use of improved legumes in farming systems. The problem is one of diffusion of technology. This will depend on the effectiveness of the extension services and the NGOs.

Tree and Shrub Fodder

Foliage from trees and shrubs are used widely during the dry winter in smallholder farming systems in the Mid-hills. Trees and shrubs are often the only source of green material of relatively high protein content used by sedentary farmers to supplement low protein diets based on crop residues (Pandey, 1982b). Their contribution varies with the agro-ecological zone but, in the Mid-hills, this ranges from 8-60% of total fodder supply depending on management. The importance of trees and shrubs as a feed resource has encouraged research workers to identify those species and develop feeding systems that will improve the contribution of these plants to the livelihoods of smallholder farmers. Well over 100 species have been identified to date in the different agro-ecological zones (Shrestha and Pradhan, 1995). Results of feeding trials have been encouraging (Shrestha and Pakhrin, 1989), but uptake by farmers has not been consistent (Joshi and Thapa, 1992) for a variety of reasons. Part of the problem is that the complexities associated with the use of tree fodder in real farming situations have not always been considered adequately during the planning and execution of the research work (Thapa *et al.*, 1997). These do not permit the straightforward introduction of new species into a diverse and fluctuating feed resources base. Furthermore, the multiple objectives that farmers must balance in planning all of their agricultural activities not only limits the acceptability of tree species, but may also lead them to specify desirable characteristics that emphasise gut fill rather than nutritive value (Thorne *et al.*, 1997a).

Sources, Production Systems and Management

Information on the habitat, life history, silvicultural characteristics, propagation methods, pests and diseases, and yields of leaf fodder from various trees and shrubs are available from Indian sources (Singh 1982). However, data describing these important aspects of fodder trees, in the Nepalese context, are more difficult to come by. A useful, general source of this information for some of the more important fodder trees is Pandey (1982b).

A wide variety of tree fodder is available. Thorne *et al.* (1998a) recorded 44 distinct species or landraces in use on farms in the Koshi Hills between June, 1993 and September 1994 (Table 12). Twenty-six of the trees were fed to buffalo, 31 to cows, 27 to oxen and 40 to goats. However, only cows (1) and goats (11) were fed fodder exclusively from the various species. Of these, around 24 made a major contribution to nutrient supplies on at least some of the farms where their use was recorded. This is in agreement with the findings of Shrestha and Tiwari (1992) who suggested that only about 20 of a possible 170 trees are used widely as sources of fodder.

Traditionally, tree fodder has been collected from forests. However, a key feature of the last twenty years has been the quite dramatic extension of on-farm plantings in some areas, to compensate for loss of access to CPRs (Carter and Gilmour, 1989). This change has been supported by a number of community-implemented schemes (e.g. Thapa *et al.*, 1990), but the technology has often spread through the initiatives taken by individual farmers (Balogun, 1987; Thorne, 1993). The numbers of trees planted on farms would appear to be highly variable, ranging from an estimated average of 17 (Hopkins, 1983) to between 300 and 400 (Fonzen and Oberholzer, 1984). An on-farm tree population of between 50 and 150 would appear to be most common situation.

Productivity

Common fodder tree species on farm holdings have yielded from 20-86kg fresh leaves and twigs/tree/year, with a dry matter content of between 100 and 600g/kg (Malla and Fisher, 1997). In this study, *Gogan* (*Sauraria nepalensis*) and *Nebharo* (*Ficus roxburghii*) were amongst the highest yielding species. Pandey (1975) reported an average yield of 70kg/tree/ year from 24 species. Pandey (1982b) suggests that an average tree may be expected to produce between 50 and 90kg of fodder in a year, but the highest yielders such as *Ficus lacor* may produce as much as 150kg/year. In *F. auriculata,* yield increased with age. At four years of age, trees yielded a total of 25kg fodder/tree compared to 210kg fodder/tree and 145kg/tree fuelwood at 25 years of age. Some 40kg of green leaf could be harvested daily through the scarce period of October to May; enough to meet the nutritional requirements of a lactating buffalo. It should be noted that the estimates of fodder yields vary depending on the stage of growth and season of cut.

It is clear that fodder yields from trees are highly variable. Amatya and Lindley (1992) found that the coefficient of variation in yields from species such as *Bauhinia purpurea*, *B. variegata, Ficus semicordata var.montana, Guazuma ulmifolia* and *Ficus glaberrima* ranged from 38.6 to 69.7%. The sources of this variation are diverse. Panday (1981) reported that trees produce their full fodder-yielding capacity at between five and 10 years of age, depending on species. Other major factors influencing yields include climate, soil type, lopping regimes and other management practices and their interactions. Amatya and Lindley (1992), working at lower altitudes in the Terai, observed higher biomass production from *Ficus semicordata* in March. On the other hand, *F. glaberrima* and *Guazuma ulmifolia* yielded most during November, and exhibited considerably lower leaf biomass yields during March. However, absolute yield is not the only factor determining the timing of lopping. Many farmers postpone lopping of trees that retain foliage in a palatable form during March to May, as this is the period when fodder supplies are restricted.

This variability presents practical difficulties for the selection of trees and shrubs for on-farm plantings to support new feeding strategies, and systematic trials to determine the yields of a range of species under different conditions are unlikely to be feasible. Simple approaches to estimating probable yields are, therefore, required so that plantings appropriate to the demands of the livestock can be made. For example, Paudel and Rasali (1996) have reported a linear relationship between diameter at breast height and tree fodder biomass production for *Badahar* (*Artocarpus lakoocha*). It is not clear how such relationships may hold for other Nepalese species, although this would appear to be valid for *Leucaena leucocephala* trees of 5-10 years of age (Amatya and Kiff, 1994).

Rapid tree growth is another important selection criterion for farmers. Growth data are not available for all fodder trees. However, *Ficus* species have been found to have a higher growth rate than *Bauhinia purpurea* and *B. variegata.* Other species, such as *Grewia optiva,* have high rates of survival and reach a height of about 0.5m in one season (FORESC, unpublished data).

Nutritive Value

Trees and shrubs used on farms over a 15-month period in the study of Thorne *et al*. (1998a), together with their dry matter, crude protein and crude fibre contents are summarised in Table 12.

Given the wide range of tree species providing fodder and their individual variability, species tend to be quite heterogeneous in terms of nutritive value. This variation is recognised and often accounted for by farmers who plan their feeding strategies accordingly. It may also be predicted from assessments made in the laboratory (Table 12), although this can present practical difficulties (Thorne *et al.,* 1997b).

Table 12: *Inventory of tree and shrub fodder fed to stalled animals on farms in the Koshi Hills (July 1993 - September 1994, n farms = 29).*

Bakaino	*Melia azedarach*	308	198	174	2
Bakhre		346	145		47
Bakimilo	*Rhus semialata*	346	145		2
Bans		346	145		215
Bans (Choya)	*Dendrocalamus hamiltonii*	506	160	286	2
Bans (Mal)	*Bambusa mutans*	337	132	247	263
Bhakimlo	*Rhus semialata*	275	111	200	2
Bhatte		342	126	213	3
Bhigune		199	114	161	1
Bhimsenpati	*Buddleja asiatica*	346	145		3
Bilaune	*Maesa chisia*	127	186		3
Chamlayo		252	229	98	20
Chilaune	*Schima wallichii*	234	143	122	36
Chiple	*Machilus gamblei*	235	233	168	39
Chuletro	*Brasaiopsis hainla*	197	169	284	5
Dhalne katus	*Castanopsis indica*	587	120	308	87
Dudhilo	*Ficus nemoralis*	338	92	197	320
Gayo	*Bridelia retusa*	247	115	218	7
Ghangaro		346	145		
Ghotli		472	144	201	309
Ghurbis	*Leucosceptrum canum*	148	210	84	4
Gogun	*Saurauia nepalensis*	573	123	175	19
Gunyalo	*Eliagnus latifolia*	245	173	157	1
Harkato		403	78	289	26
Kabro	*Ficus lacor*	398	116	277	45
Kalingare		205	119	293	1
Katus	*Castanopsis hystrix*	346	145		42
Kaulo (Laphe)	*Machilus odoratissima*	518	138	212	1
Khanue (Kasre)	*Ficus semicordata var. montana*	404	136	244	66
Khanue (Rai)	*Ficus semicordata var. semicordata*	408	162	169	21
Khari	*Celtis australis*	611	169	166	35
Kutmero	*Litsea polyantha*	370	164	235	136
Mahuwa	*Madhuca latifolia*	346	145		21
Mell		346	145		22
Nebaro	*Ficus roxburghii*	247	122	250	88
Painyu	*Prunus cerasoides*	414	175	116	96
Patle	*Castanopisis hystrix*	388	115	251	35
Phaledo	*Erythrina aborescens*	78	204	274	
Phusre	*Lindera pulcherrima*	457	160	257	50
Syalphusre	*Grewia oppositifolia*	440	158	294	1
Tanki	*Bauhinia purpurea*	402	168	352	108
Utis	*Alnus nepalensis*	353	168	111	34
Total					2250
Mean		346	148	211	52
Standard deviation		116	33	67	81

Potential for Future Development

Trees and shrubs are already well established as feed resources in the Mid-hills and, as mentioned earlier, their use as supplements to untreated crop residues probably offer the best opportunity of increasing the nutritive value of straws. There is potential for further establishment of desirable species on farm. Shrestha and Pradhan (1995) have drawn attention to the fact that there is very little information on the ranking by farmers of species for growth, DM production or lopping frequency. Similarly, the competitive effects of fodder trees on crop yields through shading and root interference are not known.

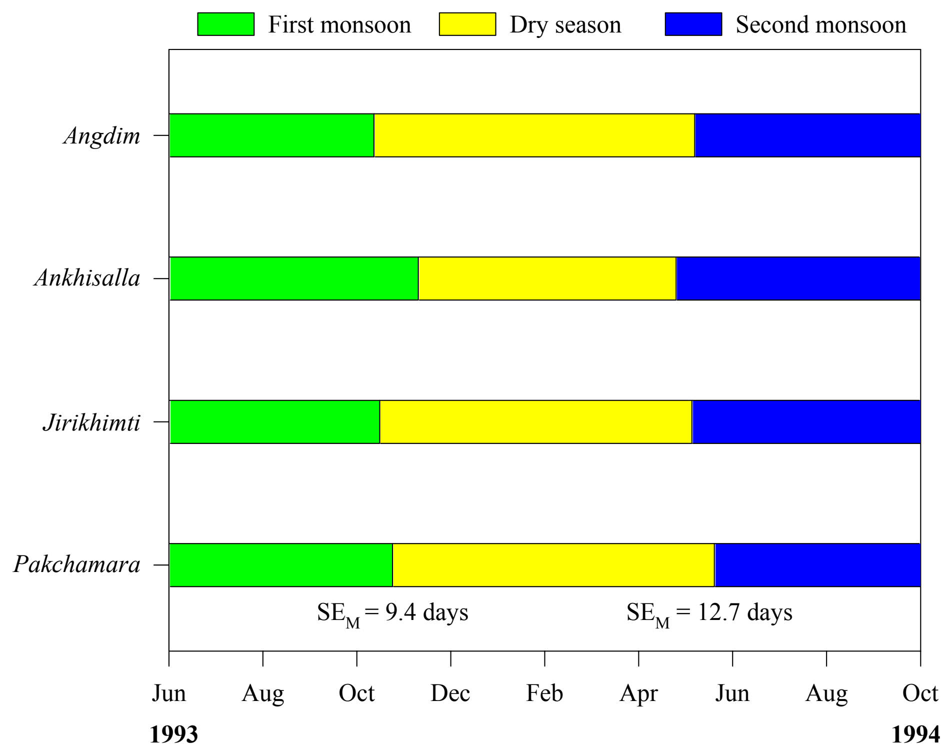
Factors Affecting Feed Supply and Utilisation

This section briefly highlights some of the key factors (biological and social) affecting the delivery of fodder to livestock on farms in the Mid-hills and, thereby, the supply of nutrients.

Location

The deeply-fissured landscape of the Mid-hills and the variable orientation of its ridge and valley systems with the paths of prevailing weather systems means that there is considerable local variation in climatic conditions. Furthermore, localised variation in soil type and access to adequate water for irrigation can mean that the resource constraints on neighbouring farms are not necessarily the same. A practical consequence of this, for the dissemination of improved technologies for fodder production and utilisation, is that recommendations derived from research must be flexible.

Figure 2: *Changeovers between and duration of monsoon and dry season feeding practices at four locations in the eastern hills (Thorne et al., 1994).*



In a study of the availability and utilisation of feed resources at four sites in the Eastern hills, Thorne *et al*. (1994) were able to confirm the marked differences that locality makes to fodder supply. A change from the grass-based feeding practices associated with the monsoon season to the crop residue-based practices of the dry season was observed on all farms over a 65-day period between October and December of 1993.

Ethnicity

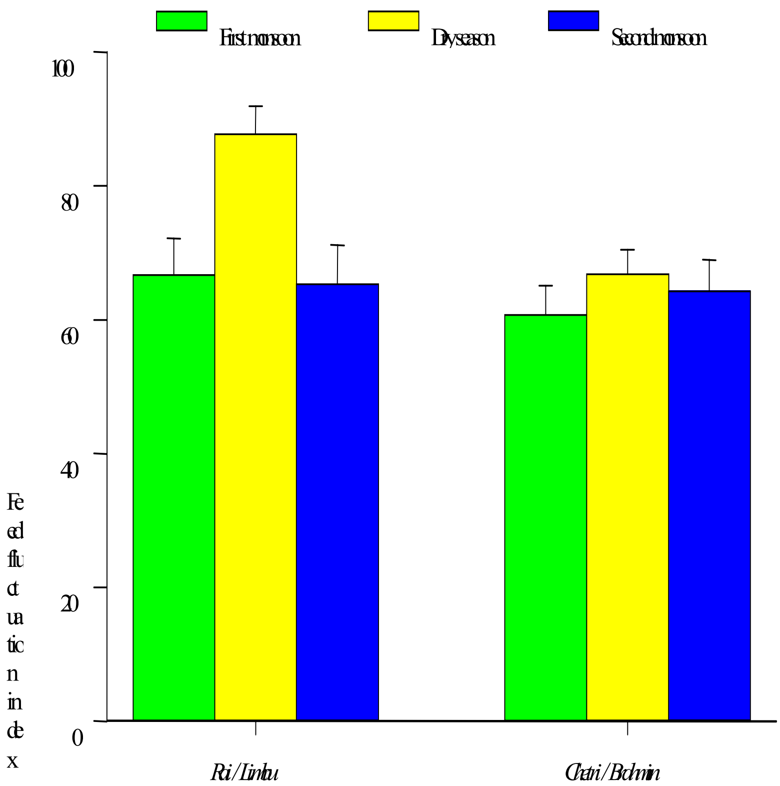
A number of cultural factors may affect the behaviour of the household and enhance or compromise its capacity to farm effectively. These may also significantly affect the feeding and management of livestock (Abington, 1992). The basic importance of ethnicity in determining behaviour was confirmed by farmers belonging to both of the main ethnic groups (*Rai/Limbu* and *Chetri/Brahmin*) in the Eastern hills (Thorne, 1993). *Rai/Limbu* families were believed to devote more time to religious observation, sacrifice more animals in the course of this, use more alcohol, be more dependent on cropping and use land in a less optimal manner. On the other hand, *Chetri/Brahmin* farmers were considered to be more innovative, better educated, keep more animals and have better land. Several of these differences are likely to impinge on the utilisation of feed resources. Interestingly, exploring these issues in group discussions was not possible as the sensitivity of the ethnicity question prevented individuals from speaking freely.

Longitudinal monitoring of feed use on the farms of *Rai/Limbu* and *Chetri/Brahmin* households has revealed a number of differences in patterns of feed utilisation (Thorne *et al.*, 1998a). In this study, *Chetri/Brahmin* farmers generally appeared to make use of a wider range of feeds than *Rai/Limbu* farmers. This was reflected by the larger number of individual feeds used (8.1*v*5.9; $P < 0.001$; $SE_M = 0.65$) and the wider representation of eight feed categories (4.6*v*3.5; $P < 0.001$; $SE_M = 0.49$) observed in the material collected for use on *Chetri/Brahmin* farms. Furthermore, a feed fluctuation index (FFI) calculated by Thorne *et al.* (1998c) indicated that there were significant differences ($P < 0.01$) between *Rai/Limbu* and *Chetri/Brahmin* farms in the extent to which they appeared to maintain consistent feeding strategies between successive fortnightly observations (Figure 5). A significant interaction between ethnic group and season ($P < 0.05$) indicated that seasonality in FFIs was due to the activities of *Rai/Limbu* farmers only, and that variation in the composition of collected feeds on *Chetri/Brahmin* farms was similar in all three seasons. The issue of such short-term variation in feeding practices is usually ignored in planning feeding trials to evaluate "improved" feeding strategies. Generally, levels of basal diets and supplements offered are kept fixed over the period of the experiment, which may extend for several months. This reduces sources of variation to a level that allows an economically-viable study. However, interpretations of the results of such studies in smallholder systems in the Mid-hills , in which feeding practices vary on a day-to-day basis, must be dubious (Thorne and Herrero, 1998).

Season

Seasonal variation in the availability of resources poses significant difficulties for farmers planning productive and sustainable management strategies (Gill, 1991).

Figure 3: *The relationships between ethnic group and short term variation in the composition of cut-and-carried fodder during different seasons (Thorne* et al.*, 1998a).*



It may be argued that these difficulties are particularly acute in mixed farming systems. The crop and livestock components exhibit a high degree of mutual inter-dependence, but seasonal fluctuations in the "requirements" of one component are often not in phase with the availability of resources from the other. For example, on farms in the Mid-hills, a period of high demand for work from draught animals occurs during the late dry season (May-June). At this time of year, there is little green fodder available and the crop residues that have been used to sustain animals through the dry period are usually close to exhaustion. Under these conditions, farmers require a sophisticated knowledge of patterns of feed availability and the responses of animals to fluctuating nutrient supplies, in order to implement feeding strategies for optimum production and sustainability. It is surprising, therefore, that the issues relating to seasonality of feed supplies in crop-livestock systems have received such scant attention. This would appear to be an essential prerequisite for the design of research to assist farmers in developing such feeding strategies. The seasonal nature of feed supplies and its consequences for animal maintenance and production have been documented for more extensive systems (e.g. Coppock *et al.*, 1986a and b). Studies in crop-livestock systems have generally focused on the preparation of gross feed budgets. These can provide a useful overview of seasonality in feed supplies and their utilisation. However, such studies are limited, in that they tend to aggregate much of the variation that must be accounted for, by the farmer or the researcher, in the detailed planning of practical feeding strategies.

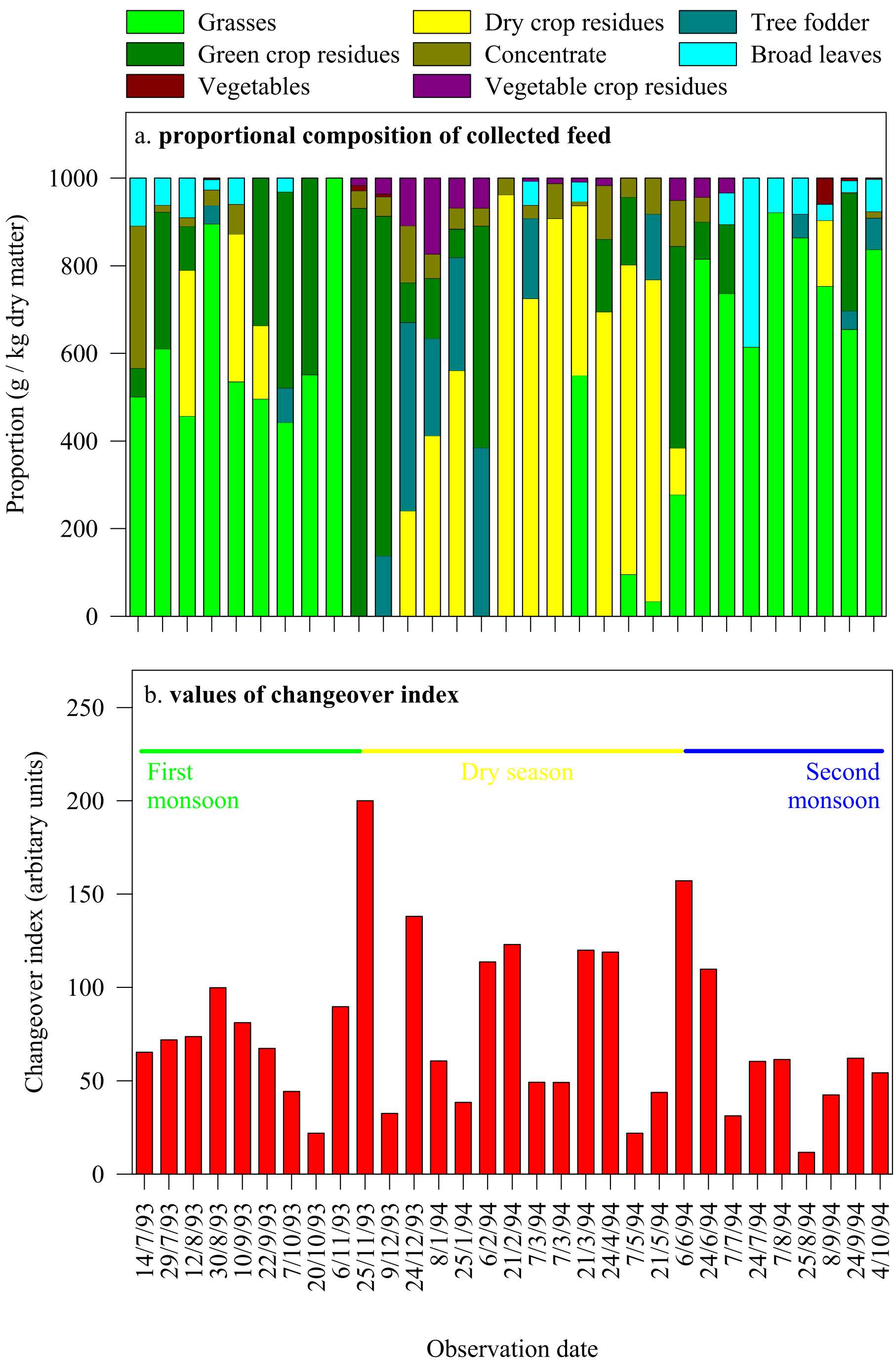
Dutt (1993), working with farmers in the Koshi Hills, describes four distinct feeding times; monsoon, post-monsoon, winter and pre-monsoon (Table 13). The period of greatest fodder scarcity is between February and May. During this time, tree fodder used in the winter months has been exhausted, or the trees have shed their leaves but the pre-monsoon tree fodder is only just beginning to come into production. The management by farmers of fodder resources focuses on trying to bridge this fodder gap with the minimal adverse impact on the ability of their animals to meet production objectives.

Table 13: *Effects of season on general feeding strategies (adapted from Dutt, 1993).*

Season	Months	Type of feeding
Monsoon	June July August September	Succulents with high nutritive value. Buffalo and cows give birth, milk production high. Feed: green grass, forbs, crop thinnings.
Post-monsoon	October November	Higher roughage, lower nutritive value Reduced production levels Feed: Mature grass supplemented with tree fodder
Winter	December January	Decreasing nutritive value with ageing of materials Further decreases in livesock production Feed: crop residues supplemented with tree fodder
Pre-monsoon	February March April May	Greatest fodder shortage Low milk production animals losing conditions but draught power may be required Feed: crop residues; limited availability of tree fodder in flush

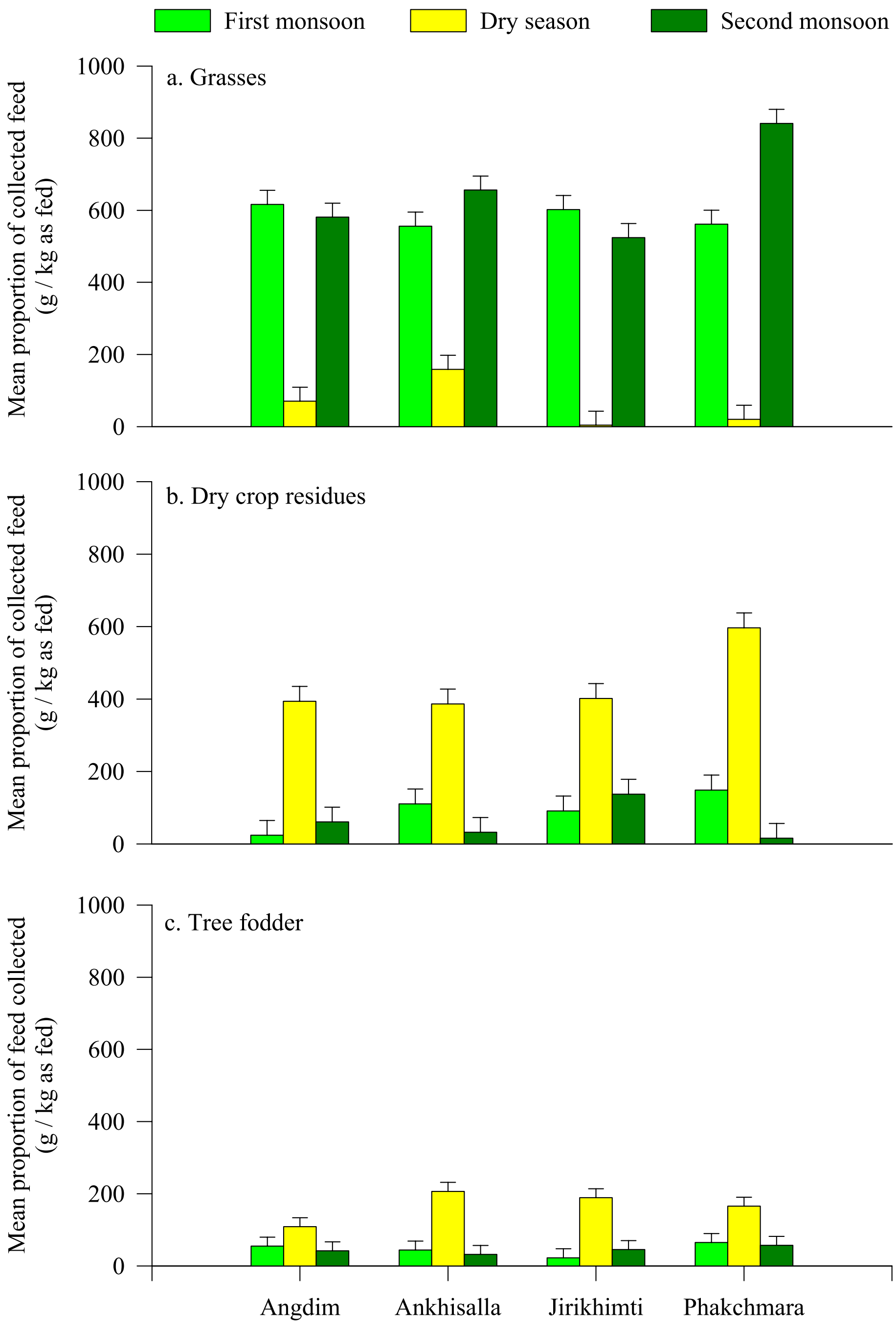
However, the fodder shortages do not occur in all areas at the same time or to the same extent. Environmental factors such as altitude and aspect may affect temperature and soil moisture conditions which, in turn, influence fodder production. The amount of on-farm and off-farm fodder, and the access of farmers to these resources will also influence the nature of the scarcity periods experienced. This is illustrated graphically by the more detailed study of Thorne *et al.* (1998a), in which the pre-monsoon fodder gap was observed at only three of the four sites under observation (Figure 6). Dutt (1993) identifies a range of primary constraints to fodder production, and distinct variation in the fodder resources used between different agro-climatic zones. Also, preferred species vary considerably amongst districts in Nepal and show distinct trends from east to west (Upadya, 1991).

Figure 4: *Example of seasonal patterns in the utilisation of cut-and-carried feeds (*Chitra Bahadur Sunawar - Angim*,* Terathum *District; from Thorne, 1994).*



The study described by Thorne *et al*. (1994) does, however, outline the complexity of the interactions amongst factors affecting the supply of feed resources and, therefore, the need for local involvement in planning interventions. Seasonal changes in the proportions of the different types of feed collected were significantly ($P < 0.001$) affected by site. The more noteworthy of these interactions is summarised in Figure 6.

Figure 5: *Interactions amongst site, season and feed type in the composition of collected feed resources in the eastern hills (Thorne* et al.*, 1994).*



Farmers at *Phakchamara* used large proportions of grass during the second dry season in comparison with farmers at the other sites, where proportions were generally similar during both monsoon seasons. However, farmers at *Ankhisalla* collected more than twice the proportion of cut grass as part of their dry season feeding regimes than farmers at any of the other three sites. Proportions of dry crop residues in the feed collected during the dry season by farmers at *Phakchamara* were also higher than at the other sites where levels of use were, again, similar. The proportion of tree fodder was low in the feed collected by farmers at all sites during the two monsoon seasons.

Nevertheless, a wide variation in the proportion used during the dry season was observed. The greatest contribution was made amongst farmers at *Ankhisalla,* where the proportion in the collected feeds (207g/kg as fed) was almost double that in feeds collected by farmers at *Angdim* (109g/kg as fed).

Some Current Research, Extension and NGO Activities

A considerable number of organisations are involved in research and extension activities related to increasing and improving fodder resources. Amatya (1994) identified thirteen organisations, most of whom have concentrated on the introduction of fodder tree species, assessment of their growth rates, lopping trials and tree-crop interactions.

Begnas Tal Rupa Tal Project

The field survey conducted in 1996, as part of the CARE (Nepal) Begnas Tal Rupa Tal (BTRT) project, found that most *Ficus* species (*F. lacor, F. glaberrima, F. roxburgii), Dendrocalamus* species *and Castanopsis indica* cast more shade on adjacent farm crops than taller and less vigorous trees like *Leucaena* species and *Melia azedarach*. Furthermore, the report indicated that self-sufficiency in fodder and fuelwood availability increased over time (four years) along with an increase in cereal and fruit production. It does not indicate what quantities of fodder, cereal and fruit crop yields were recorded in the study. The results were based solely on farmer interviews.

Environment Camp for Conservation Awareness

Environment Camp for Conservation Awareness (ECCA) is a national NGO which has promoted the establishment of fodder tree species both on-farm and off-farm, with the help of youths in *Janakpur* District. The youths of a particular locality (focus community) are encouraged to form a group called the Natural Club. This is then responsible for implementing the programme locally. There are 15-20 such clubs in the District. Fodder species such as *Leucaena* have been planted in the compounds of schools and municipal buildings. Strengthening and training of FUGs are amongst other extension activities being carried out by the ECCA. The Natural Club is responsible for monitoring and follow-up of extension activities. The programme has so far been successful in developing a self-monitoring system within each project area and in reaching many farming households. The Natural Clubs have also introduced and tested new species in the fields of farmers (P. K. Shrestha *pers. comm.*).

Social Action for Grassroots Organisation

Social Action for Grassroots Organisation (SAGUN) is a Kathmandu-based NGO, active in *Kabhre Palanchok* and *Sankhuwasabha* Districts. SAGUN has launched trials to investigate which combinations of fodder tree species are suitable for bridging seasonal gaps in fodder supply. SAGUN works through local NGOs which have established private nurseries of indigenous and exotic species. The fodder seedlings are distributed through an inter-nursery exchange system. The PRA wealth-ranking exercise of SAGUN found that villages with smaller average landholding size were more resistant to the promotion of new fodder trials (Mukta Lama *pers. comm.*).

Service Extension and Action Research for Communities in the Hills

The Service Extension and Action Research for Communities in the Hills (SEARCH/Nepal) has initiated a fodder tree programme in *Katike Deurali* VDC of

Kabhre Palanchok District. Local fodder groups from six wards of this VDC have formed a central committee which consists of five members. This committee is responsible for monitoring and follow-up of private nurseries. The seedlings are provided free of charge by a local NGO called *Gramin Samudaik Bikash Sanstha* (GSBS). The money for nursery establishment was given to GSBS by SEARCH/Nepal through a United Nations Development Programme (UNDP) grant (Bidur Thapa *pers. comm*.).

Centre for Environmental and Agricultural Policy Research Extension and Development

The Centre for Environmental and Agricultural Policy Research Extension and Development (CEAPRED/Nepal), a national NGO, has been working in *Baitadi* District in the western region for the past two years. This NGO has been facilitating FUG formation and establishment in *Tripura Sundari* and *Durga Bhagawani* VDCs of *Baitadi* District. CEAPRED/Nepal works through local bodies known as Production Groups which also organise saving and credit scheme programmes. Community nurseries have been established in both VDCs. The nursery *Naike* is paid for the work (Rs 500-1000/month depending upon workload). Several patches of communal grasslands have been rejuvenated by planting fodder trees and grasses. The District Forest Officer, following approval from the Chief District Officer, will authorise the communities to create plantations on these patches with the aim of creating community forests. CEAPRED provides grant money to the Production Group who, in turn, charge Rs 1.0/sapling to individual farmers and keep the money in a group account. In this way the groups are becoming self-sufficient in the business of fodder seedling production. Approximately 40,000 cuttings of Napier grass were distributed last year. Other fodder species include *Dinanath*, stylo, Molasses grass, *Desmodium* species and Brome grass. *Tanki* (*Bauhinea purpurea*) and *Kutmiro* (*Litsea monopetala*) are among the fodder tree species being cultivated.

Centre for Integrated Agricultural and Cooperative System

The Centre for Integrated Agricultural and Cooperative System (COSIS), an NGO registered in Kathmandu District, has initiated trials involving the fodder tree species *Ipil (Leucaena* species), *Tanki* (*B. purpurea*), *Kimbu* (*Morus alba*), *Gliricidia sepium,* and *Sesbania sesban* together with Napier grass and *Desmodium* species. These have been planted in the fields of farmers and in the grasslands in *Baluwa* VDC of *Kabhre Palanchok* District. *Kimbu, Ipil* and Napier grass are now distributed widely. Some 250 farmers were involved in this fodder and pasture programme, as part of the Dairy Cooperative Programme of the District Development Committee (DDC) in *Dapcha*, *Kabhre, Puranogaon* and *Mahadevstan* VDCs of *Kabhre Palanchok* District and *Phataksila, Sikharpur* and *Talamarang* VDCs of *Sindhu Palchok* District. In the winter, trials with oats, vetch and berseem fodder are scheduled to start with almost 500 farming households in *Sindhu Palchok* and *Kabhre Palanchok* Districts. Already, three community FUGs of *Mahadevstan* VDC in *Kabhre Palanchok* District have already planted fodder trees and grasses on degraded fallow lands as part of this dairy promotion programme (Gopi Sedhain *pers. comm*.).

Nepal Agroforestry Foundation

The Nepal Agroforestry Foundation (NAF) has undertaken lopping trials of the fodder tree species Mulberry (*M. alba*), *Gauzuma ulmifolia*, *Bhatmas*e (*Flemingia congesta*) and *Sesbania sesban* in *Hinguwapati* (*Kabhre* District) and *Majhigaon* (*Sindhu Palchok* District) over a cropping cycle of 12-months (1990-1991). The results of the Mulberry lopping trial revealed an interesting relationship between fodder yield and a combination of various levels of thickness, stump height and harvest interval. When the stem is thin, increased harvest intervals tend to produce lower yields at both the 100cm and 150cm stump heights. The yields also decrease with increased harvest interval (e.g. 60 days to 90 days) and increased stump height. Farmer observations indicated that the greatest yields were obtained from trees cut close to the ground. This treatment was not included in the trials because of the small size of plants at the start of the experiment. Hence, it appears that coppicing produces higher yields than lopping. Further trials are required to validate this. The lopping trial conducted on *G. ulmifolia* revealed that fodder yield increased with an increase in tree height. However, the relationship between tree height and fodder yield is not directly proportional. There is a decreasing rate of fodder return with height increment. The optimum cutting height seems to be about 160cm, above which the increase in fodder yield is not significant. The lopping trial results with *S. sesban* showed that the average fodder yield per tree was highest with harvesting intervals of 2.0-2.5 months. Field observations showed poorer regeneration with more frequent removal of new leaves and shoots.

Collaborative research between NAF and FORESC during June 1995 and November 1996, on the identification of appropriate fodder technologies for marginal farmers, concluded that simple technologies are adopted more easily and successfully by farmers than sophisticated ones (Elliott, 1996). For example, hybrid Napier grass cv. NB-21 was introduced into villages several years ago but did not spread widely, though there is a good market and a need for nutritious fodder to boost milk production during the dry season. This is because farmers were unaware of the need to replant a slip/clump every 2-3 years to maintain productivity, and did not understand the importance of adopting the correct harvesting methods. Simple messages to farmers regarding management of new innovations need to be repeated and reinforced by demonstrations. On the other hand, *Chrysopogon* species, a native grass which is more tolerant of low soil fertility and moisture levels than introduced species, grows well on terrace walls. Unlike hybrid Napier grass cv.NB-21, it does not requires space at the edge of the terrace and does not, according to the perceptions of farmers, compete with crops. *Kutmiro (Litsea monopetala*) is a local fodder tree, which also has limited effects on crop production. The species is propagated easily and is, therefore, widely valued by farmers. The author concluded that mixed planting of indigenous and exotic species is most likely to provide the optimal combination of fodder, fuelwood and timber required by farmers.

Nepal Australia Community Forestry Project

Gilmour and Nurse (1991) of the Nepal-Australia Community Forestry Project described how edible tree leaves are used for animal fodder, particularly during the winter months, when grass and other ground herbs are in short supply. Large quantities of dead herbs are collected from the forest floor and used for animal bedding, which ultimately provides a good source of organic fertiliser when mixed with manure. This has become a good substitute for chemical fertiliser. In the same report, the author stated that the number of trees on private land had increased threefold over a 24-year period (1964-1988). The measurements were made in eight selected catchment areas across *Jhiku Khola* sub-watershed in *Kabhre Palanchok* District. Average tree density on upland areas in this study increased from 65 to 298 trees/ha. This was due largely to the initiatives of farmers rather than external encouragement from government projects and NGOs.

Dolakha-Ramechhap Community Development Project

The Dolakha-Ramechhap Community Development Project is funded by the Swiss Agency for Development Cooperation (SDC). The project aims to encourage farmers to increase their private feed resources, particularly fodder trees and Napier grass. The project has also promoted a home-nursery programme, with 3,500,000 grass plants and fodder tree saplings provided to farmers through these nurseries. Species used included hybrid Napier grass cv. NB 21, stylo, molasses grass, *Leucaena* species, *F. congesta, M. alba, B. purpurea* and *L. monopetala*. After three years (1993-1995) the results were disappointing, as less than 50% of the plants had survived. The reasons for this low survival rate were summarised by a Mr Khagendra Siktel as follows:

- Dryness of the area.
- Farmers expected a greater provision of services through the programme.
- Fodder trees were low on the list of priorities of farmers and, consequently, were planted on very marginal land.
- Seasonal free grazing was practised on farmland.

In response to these failures, the SDC has altered its policy to emphasise demand-based programmes rather than fulfilling arbitrary targets. The project has changed its strategy of support to farmer groups, by encouraging them to use their own initiatives to fulfil the programme objectives rather than becoming over-reliant on external support (Schular, 1997). Farmer interviews proved to be much more effective than field measurements for the collection of information on plant survival rate and growth. Schular identified the following criteria for the selection of support areas:

1. Begin with the best land.
2. Begin on a small scale with several farmers.
3. Implement demonstration plots with farmers.
4. Profile and consult with local institutions.

Action Aid Nepal

Action Aid Nepal (AAN) is promoting greater cultivation of fodder on-farm in conjunction with an up-grading programme for goats. Fodder grass slips (119,008) of *Setaria anceps* and hybrid Napier grass cv. NB-21 were distributed to almost 600 households during 1993/94. There was an abnormally low survival rate (20%) of planted species, including hybrid Napier grass cv. NB-21, *Leucaena, Bauhinia* and *Morus* species. This may have been due to a lack of commitment on the part of farmers.

The Agriculture and Common Property Resource Development Programme of the AAN involved the rural poor in *Sindhu Palchok* District. A significant number of fodder saplings and grass cuttings were distributed free of cost to individual farmers. Timely digging of pits and transfer of saplings from nearby nurseries helped to ensure a good survival rate (60%-75%). However, this programme has not transferred well to other areas. Now, AAN has transferred its emphasis to home-nurseries with the hope of making the programme sustainable.

New ERA

The New ERA study on " Community forest management with relation to population" was conducted in 1996 in *Lele* VDC (*Lalitpur* District). The results showed that tree species such as *Lapsi* (*Choreospondis axillaris*), *Painyu (Prunus cerasoides*), *Utis* (*Alnus nepalensis*), *Bakaino* (*Melia azedarach*) and *Chilaun*e (*Schima wallichii*) have not been promoted widely. Nine out of ten households have less than 10 trees on their farms. Some 84% of the population obtained fodder and grass from community forest areas, 12 % from private lands and 2 % from government forests. Most of the respondents (90%) said that there has been no encroachment into forest areas since the implementation of the CF programme. Very few people (less than 9%) sell forest products and none sells fodder. Stall-feeding is practised by 84 % of the respondents. However, only 32 % of these people strictly adhere to this practice all the year round. Nearly 10 % practise free grazing for nine months and 23 % for six months, usually on communal pastures.

The report concluded that people have participated actively in the protection of community forests, once degraded areas have been rejuvenated. This has been achieved through controlled use of the forest and by using fodder and fuelwood from private sources along with crop residues.

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