

Conclusions and recommendations

The conclusions and recommendations were prepared at the end of the meeting by the participants divided into three working groups according to the three main subject areas covered as follows:

I. The Resource Base:

Chairman (in session)	R.A. Leng
Rapporteurs	M. Baumer C.P. Chen
Members	A. El Aich R.A. Halim F. Riveros

II. Main fodder trees and fodder shrubs, both legumes and non-legumes, as protein sources for livestock. The Nutritional Aspects:

Chairman (in session)	D.V. Rangnekar
Rapporteurs	C. Devendra M.S. Dicko
Members	F. D'Mello M. Kass R.A. Leng Ravindra Kumar

III. Harvesting and Feeding Systems. Regional and Country Case Studies:

Chairman (in session)	F. D'Mello
Rapporteurs	T.R. Preston F.A. Moog
Members	P. Amir N.P. Joshi D.V. Rangnekar O.B. Smith

Conclusions and recommendations elaborated by each group were discussed, amended and adopted by all participants at the final session. This last session was the concluding plenary session. It was chaired by the FAO officer in charge of the consultation.

In order to plan the debates and help form conclusions and recommendations, the following themes of discussion were suggested in advance to the three groups:

- A. What is the established knowledge on the subject and what can be applied immediately?
- B. What research should be done locally concerning the technologies which are to be introduced?
- C. What fundamental research is needed for further development of technologies? This fundamental research is supposed to be done in established research institutes.
- D. What kind of training is needed in developing countries to ensure good research and transfer inside the country?
- E. How can the technologies be transferred?

The participants were obviously free to introduce other themes of discussion, if necessary.

SESSION I. THE RESOURCE BASE

Trees and shrubs contribute, *inter alia*, to sustainable agriculture and provide a high value fodder for livestock. Their browse production role within livestock systems should be considered in close liaison with all their other roles and within the global context of the environment. Development is for the benefit of man. The target is to gain a greater understanding of how to use trees and shrubs for improved livestock production.

A. Established knowledge and application

Trees and shrubs have multiple functions, especially for livestock production. A large number of trees and shrubs are eaten by livestock, wildlife and various animals (silkworms, fish, honeybees, agoutis etc...);

a short list of the main ones could be established for each ecological zone but only a few species have been studied and often with insufficient scientific definition.

The role of trees and shrubs varies with the climate: the more arid the climate, the greater the use of trees and shrubs, even to the point where animals depend exclusively on them. Within each climatic zone, trees and shrubs are more important in the dry seasons. They can be used as basal feeds or as protein supplements.

A lot of nutritional data exist but these were often obtained with different methodologies on materials of uncertain provenance, age or definition and on a limited number of species.

The feeding value of trees and shrubs depends on factors such as digestibility and deleterious compounds which are often not considered in most nutritional studies. Seasonal variation in nutritive value has also been ignored in nutritional evaluation.

B. and C. Local and fundamental research

1. Research should be strengthened.
2. Technical validity, social acceptability and economical viability should be considered on the establishment, protection and increasing use of fodder trees and shrubs.
3. The knowledge of local people should be more often and more fully taken into consideration. Communication between concerned people and scientists should be increased.
4. A global data bank proposed by ICRAF should be adopted to allow rapid access to information. The list of useful species of economic importance should be enlarged in each ecological zone.
5. Selection of fast growing and high yielding varieties has still to be done.
6. Standardization of methodology for evaluation of trees and shrubs is also still required. At least in arid zones, carrying capacity, stocking rate and other similar concepts should be replaced, if possible, by concepts describing the grazing pressure and patterns of utilisation, as they do not take into account the animal owners' strategies.

7. Interactions between trees and shrubs, animals, crops and environment, within the feeding systems should be studied.
8. Research on processing technologies, on allelopathy, on deleterious factors and on technology for processing fodder should also be developed.

D. Training

A multidisciplinary and systems approach should be taken into consideration within training programmes dealing with trees and shrubs. Animal scientists should be more aware of sociological, agronomical and forestry aspects and *vice versa*.

Livestock owners and farmers should be fully associated in an integrated manner to participate in research and development programmes.

E. Technology transfer

Technologies for planting and management of trees and shrubs should be adopted in each zone and in relation to potential demand and possible success.

Germplasm exchanges, creation of tree and shrub fodder banks and creation of botanical conservatories should come first and should include whenever possible the utilisation of a few specimens of endangered trees and shrubs species for germplasm conservation.

Based on ecological zoning, working groups on trees and shrubs should be formed, with FAO and other international organizations' support, to exchange experience and information.

SESSION II. NUTRITIONAL ASPECTS

The main conclusions and recommendations within this session were the following:

- The value of trees should be considered as multipurpose.
- There is a need to set up systems which involve the use of multipurpose fodder trees taking into consideration humans, animals, and the environment and the interaction between them. Potential areas where such work needs to be undertaken are North western

India (Rajasthan) and also parts of semi-arid and arid Africa (Kenya, Mali and Senegal, for instance).

- In ruminant feeding, considerable evidence exists of beneficial responses to production due to the use of some tree fodder supplements in terms of live weight gain and milk production. There is a need for a wider application of these research results in large scale on-farm trials. Continuing research is necessary to focus on other fodder trees on which there is inadequate information.
- In non-ruminant nutrition, considerable potential exists for partial replacement of conventional protein sources, with the benefit of reduced cost of feeding in small farm systems.
- On-farm research and development activities necessitate strengthening of research-extension linkages in participatory work with farmers involving efficient delivery systems.
- Research and development activities need to ensure that the use of these supplements are cost effective and economically justified in all production systems.
- Many of the fodder trees and shrubs have, as toxic or deleterious factors: mimosine, cyanogens, lectins and tannins. Practical and cost-effective methods need to be demonstrated to overcome problems associated with their use. Tannins are to be considered as the most important deleterious principles in tree fodder and shrubs. It is recommended that more research be undertaken to determine appropriate methods of alleviating these deleterious effects in order to upgrade the quality of the protein supplements made with these feeds.
- In *Enterolobium cyclocarpum*, there exists an antiprotozoal substance that demonstrated reduced protein requirements and good performance in sheep. There is a need to explore more fully similar forages and inherent substances which could provide low cost supplements for ruminants in developing countries.
- Increased informal training is recommended for technicians in undertaking fundamental research, for instance tannins analysis, and for promoting the utilization of research results.

- There is also a concurrent need to accelerate information exchange on the subject as well as to promote increased contact between scientists working in this field within and between regions in the developing countries. This can be achieved through meetings and also exchanging visits.

SESSION III. HARVESTING AND FEEDING SYSTEMS. REGIONAL AND COUNTRY CASE STUDIES

A. State of knowledge and what can be applied

a) Role of trees and shrubs

Trees and shrubs play a critical role in integrated farming systems because:

- The leaves are sources of protein for both ruminant and monogastric animal species
- Stems and branches can be used as firewood or as fuel in gasifiers
- They control erosion
- Most species, even non-leguminous ones, are associated with organisms which fix atmospheric nitrogen
- The decaying organic matter on the soil derived from the fallen leaves acts as a mulch and a sink for oxidation of methane
- The standing biomass is a living sink for carbon dioxide
- They provide shade, are windbreaks and conserve soil moisture
- Most trees and shrubs are deep-rooted and resistant to drought and unfavourable soil conditions. They are particularly valuable as supplements and sources of fuel in such regions
- They are also the cheapest feed resource for resource-poor farmers

b) Farming systems

Five major farming systems have been identified where trees and shrubs are being used extensively. Examples are taken from specific countries, but the practices are widespread in the regions and subregions in all major continents. In addition, two other systems which relate to North Africa and the Middle East must also be considered.

1. Systems for rehabilitating arid and semi-arid regions using *Prosopis* spp.

Prosopis tamarugo was established on some 26,000 ha of the Tamarugal Pampa in Chile in the decades of the 60s and 70s. This region is a desert, characterised by almost complete lack of rainfall (average is 0.7 mm annually) and temperatures varying from 16 to 31°C with 52% relative humidity. Carrying capacity with sheep has risen from 1 animal/ha in the early years to 6-10/ha after 15 years. At this stage the productivity (leaves and fruit) from the forest is assessed to be 6,600 kg/ha (55 trees/ha).

Prosopis juliflora was introduced into N East Brazil in 1942, from Peru, and has spread extensively throughout the region. In this semi-arid region average yields of pods are 2-3 tonnes/ha/year; however, on soils of slightly higher fertility, yields up to 6 tonnes/ha/year (comparable yields of maize are 600 kg) can be obtained with 100 trees/ha while, with irrigation during flowering (600 litres/tree every two weeks), yields as high as 16 tonnes/ha have been reported. The feeding value of the pods (50% sugars) is only slightly inferior to that of cereal grain, when heat-processed to neutralise non-nutritional compounds.

Prosopis cineraria has an important place in the economy of the Indian desert where annual rainfall is from 150 to 500 mm. It produces flowers and fruit in the driest months when all other species are leafless and dormant. With 40 trees/ha, income from fodder, timber and fuel wood can reach US\$ 500.00/year. The tree is an important feed resource in Oman where large forests are still found.

2. Agroforestry systems such as alley farming in West Africa

This system was derived from "alley cropping" or avenue cropping, in which food crops are grown in 4-5m wide alleys between hedgerows of trees and shrubs, preferably legumes. The hedges are trimmed at planting and during crop growth and the prunings used as mulch and fertilizer. In alley farming, part of the hedgerow material (about 25% is the recommended proportion) is fed to livestock especially small ruminants. *Gliricidia* and *Leucaena* have been the most widely used trees in the humid and semi-humid lowlands in conjunction with food crops

such as maize and cassava. Alley farming can also be managed to provide larger quantities of fodder for livestock in trees-only or tree-grass plots.

3. Farm forestry in Nepal and India

In India, trees are planted along the bunds, water channels or on community lands. In Nepal forests they are integrated with crop production on terraces.

In India, commonly used species are *Acacia* spp., *Albizia* spp., *Ficus* spp., *Sesbania* spp., *Prosopis* spp., *Ailanthus* spp., *Ziziphus* spp., *Hardwickia* spp., *Pithecellobium* spp., *Erythrina* spp., *Enterolobium* spp., *Azadirachta indica* and *Dalbergia* spp.

Most of these species are found also in Pakistan and Nepal, as in the sub-continent in general. Additionally in Nepal, there is widespread use of *Artocarpus lakoocha*, *Leucaena*, *Quercus*, *Salix*, *Dendrocalamus*, *Budleja asiatica*, *Grewia ophra*, *Bauhinia* spp., *Litsea polyantha*, *Castanopsis* and *Morus alba*. There are three systems of usage:

- Extensive, by pastoralists completely dependent on livestock who depend on tree foliages and shrubs almost exclusively during the dry season.
- In rain-fed cropping areas where livestock are an integral feature of the economy. In times of drought livestock are the major source of income and this is when trees and shrubs are most used.
- Intensive cropping in irrigated areas where stress is on cash crops and trees are essential supplementary feeds especially for livestock owned by landless labourers who work in these areas. In all cases the trees and shrubs are considered as an important source of fuelwood and of timber. In many cases they also provide fruit for human consumption.

The above pattern generally reflects usage of trees and shrubs in the subcontinent as a whole. In the high elevation areas, trees and shrubs are the major feed resource during the dry season.

4. Trees and livestock in upland cropping systems

In the Philippines, trees are integrated with many farming systems. In Batangas, *Leucaena* has had a major impact being used in intensive fattening while in Cebu a prosperous export trade was developed in leaf meal. However, many other species are commonly used: for example *Gliricidia*, *Sesbania*, *Moringa oleifera* and *Cocos nucifera* during the dry season.

5. Intensive integrated production of livestock and fuel from sugarcane, multipurpose trees and water plants in the wet tropics

In this intensive integrated system for the wet tropics, sugarcane is fractionated into juice for pigs and ducks, the tops for hair sheep and the bagasse for fuel. The leaves of *Trichantera gigantea* are used to replace 75% of the soyabean-based supplement for the pigs during pregnancy. The foliage of *Gliricidia sepium* provides almost all the protein for the hair sheep flock whose basal diet is the cane tops and a molasses-urea block. Net yields exceeding 4,000 hg/ha have been reported and methane:meat ratios are less than 0.1, compared with 1.0 for typical pastoral systems.

6. Halophytic steppe and desert farming systems

This system integrates livestock, especially dromedaries and goats, and fodder trees and shrubs that are drought resistant and salt tolerant. It is largely represented by a belt starting in North Africa and continuing to the Middle East (more than 1.5 millions km²). Rehabilitation of these desertic lands with species such as *Salsola spp*, *Suaeda spp*, *Traganum nudatum*, *Atriplex halimus*, *Acacia raddiana* and *Tamarix spp* is of a great value for the dromedary which is gaining a lot of interest. Such rehabilitation helps to decrease the desertification risk.

7. *Artemisia* Steppe farming system

This shrub is widely distributed in North Africa and the Middle East, i.e., it covers more than 11 million hectares just in North Africa alone. This fodder is highly palatable and well adapted to the arid environment. Sheep holders found *Artemisia* very useful as shrub. Improvements of the range lands dominated by *Artemisia* can be achieved through a proper grazing management. Association of *Artemisia* with other fodder trees and shrubs such as *Acacia cyanophylla*, *Atriplex mummularia* and *Prosopis* spp. lead to an increase in animal production in a sustainable manner.

It is stressed that much of the experience with trees and shrubs is derived from farmers' experience and has long been a part of the culture of the farming communities in the different ecological zones.

With a more critical understanding of the role of trees and shrubs and of the factors influencing their nutritive value and productivity, the impact of these different systems could be increased considerably.

It is also stressed that it is the multipurpose role of trees, and especially their use as fodder, which is rendering this practice increasingly attractive in mixed farming systems.

B. On-Farm Research

There is a need for:

- Socio-economic surveys to evaluate the role of multipurpose trees in mixed farming systems and especially their role as sources of fodder. Diagnostic studies should pay particular attention to the technical, political, and socio-economic aspects of incorporating multipurpose trees in farming systems.
- A data base which describes traditional practices, ongoing research, resource persons, technology options and sources of information.
- Establishment of networks in equatorial regions of the three major continents. These should serve to promote activities in research, training and communication with respect to the use of trees and shrubs.

- Research on multi-purpose trees and shrubs must be interdisciplinary, since it involves forestry, agronomy, animal science and socio-economics. Support should be given preferentially to established groups that have such an interdisciplinary approach.
- Research is required in the following area:
 - The balance between crops, trees and pastures.
 - Evaluation of yield of pods and flowers on an individual tree and area basis, harvesting procedures and the utilization of these in practical feeding systems.
 - Establishing response curves relating inputs of foliages and animal performance on different basal diets (e.g., crop residues).
 - Use of mixtures of leaves from different species to optimise tannin contents and thus improve bypass protein characteristics.
 - On-farm processing of leaves (e.g., acid and alkali treatment) to aid conservation and to improve nutritive value especially for monogastric species.
 - Evaluation of gasification as a means of obtaining fuel from low-density ligno-cellulosic material.

C. Problem-orientated Research on-station and at international Centres

- Evaluation of local species of trees and shrubs, currently used widely by farmers, but for which there is negligible information.
- More precise information on secondary plant compounds, their effect on the animal, which of these are useful, and, if they are toxic, what kind of treatment is required for them to be neutralized. The approach should relate to the contrasting needs of ruminant and monogastric animals.
- In view of the dramatic improvements that can be obtained by defaunating ruminant animals fed tropical feed resources and the demonstrated anti-protozoal effects of tree species such as *Enterolobium cyclocarpum*, there is a need for more comprehensive testing of other species. This should be linked with known farmers' experi-

ence concerning the benefits of specific tree species on animal performance.

- Development of methods for conserving leaves, flowers and pods for use in lean periods.
- Studies on tree management for animal feeding.
- Studies on the effects of trees and shrubs on animal health over long periods.
- Studies on development of simple tools to facilitate harvesting of branches and pods.
- Design of gasifiers adapted to using low-density ligno-cellulosic material.
- Development of interactive "expert systems" software based on the ICRAF model and specifically directed to the needs of technology transfer, the aim being to provide information on appropriate species and management for specific ecological zones and farming systems.

D. Training

As with research so with training, the approach should be multidisciplinary and in-service. There is a need for postgraduate programmes which include socio-economics, forestry, agronomy and animal production. Short courses (1 to 2 weeks) are a valuable means of broadening the perspectives of professionals from specific disciplines, and for initiation of advisers involved in rural development (e.g., workers from NGO's). At the farmers' level, visits to regions where technologies are being applied is the most effective way of technology transfer. There should also be incorporation in high school curricula of the importance of trees and shrubs as components of sustainable low-input farming systems. There should be a greater involvement of women both as teachers and trainees, and in the development of training materials directed at women.

Study tours to promote exchanges among countries with similar ecological zones (TCDC approach) should be encouraged. Regional training courses are also effective means of technology transfer.

E. Transfer of technologies

Ensure the "farmer first" approach at all levels. Identify successful farmers and then publicize their experiences through audio-visual aids and techniques. Emphasis should be on the role of trees and shrubs in the overall development process especially as this relates to protection and enrichment of the environment.

It must be noted that at the end of the presentation by the session's rapporteur, Dr. Preston, of the conclusions and recommendations elaborated within Group III, there was a general and very supportive agreement from the participants to consider this very comprehensive and attractive presentation as the final text of the experts' conclusions and recommendations.

Nevertheless, the participants insisted, with regard to this text, on the necessity to include, besides the five major farming systems identified, the halophytic steppe and desert farming system as well as the *Artemisia* steppe farming system identified in North Africa and the Near East.

Participants also insisted on the necessity to clearly take into account the following:

- marketing aspects (foliage, bark, pods, seeds etc...);
- well defined objectives for research and projects formulation;
- women role and involvement in research and development;
- attention to be also focused on wastelands;
- involvement of governments and NGOs in development.